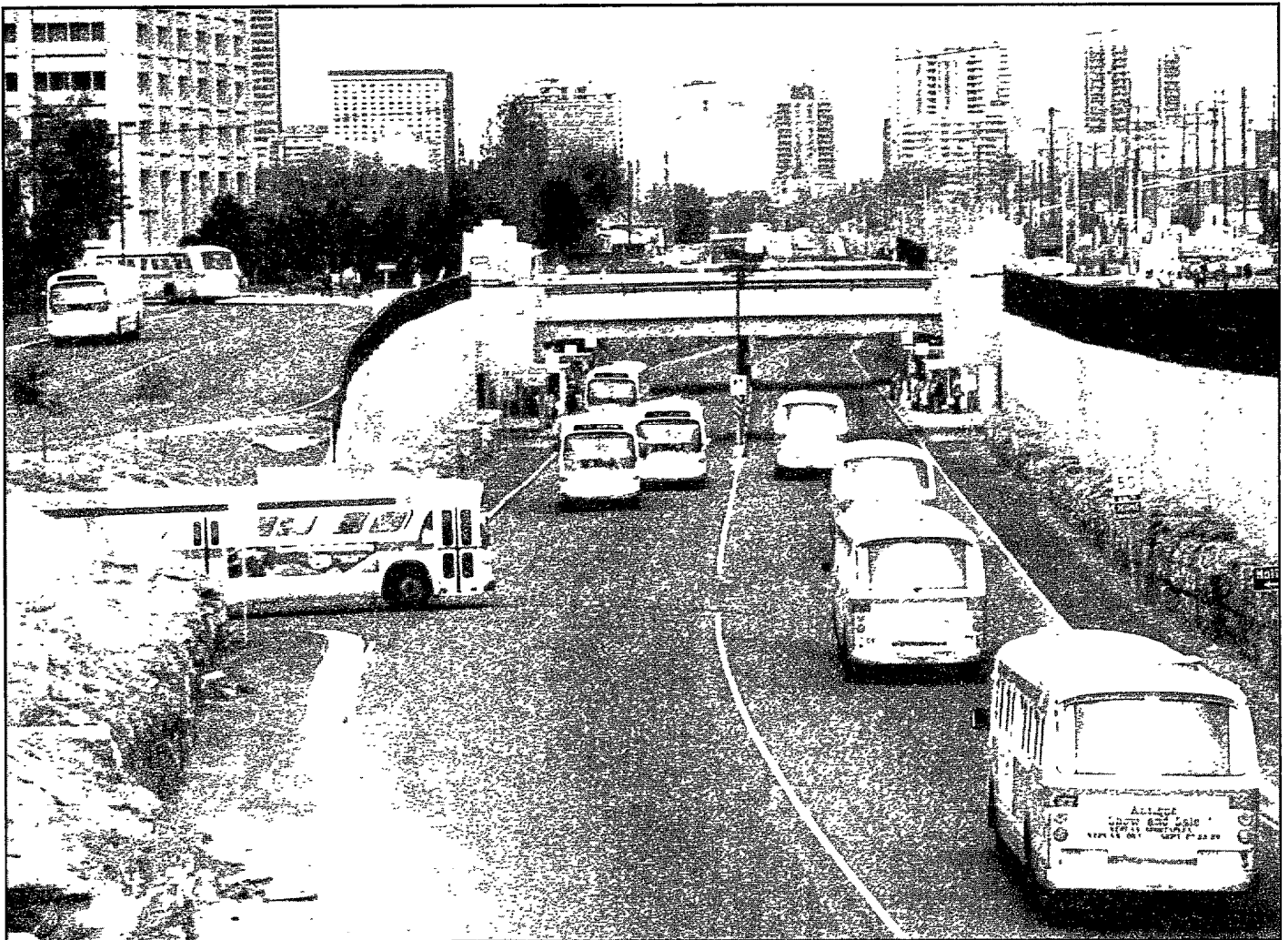


U.S. Department
of Transportation

The Bus Transit System: Its Underutilized Potential

May 1994



FEDERAL TRANSIT ADMINISTRATION

The Bus Transit System: Its Underutilized Potential

**Final Report
May 1994**

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SI Conversion Table

<i>SI unit (symbol)</i>	<i>DIMENSION</i>	<i>English unit (symbol)</i>
<i>Conversion factors</i> (for conversion in the direction of the arrow multiply by the number provided)		

LENGTH		
millimeter (mm) centimeter (cm) meter (m) kilometer (km) $10^3 \text{ mm} = 10^2 \text{ cm} = 1 \text{ m}$ $10^3 \text{ m} = 1 \text{ km}$		inch (in., ") foot (ft, ') yard (yd) mile $36 \text{ in.} = 3 \text{ ft} = 1 \text{ yd}$ $5280 \text{ ft} = 1760 \text{ yd} = 1 \text{ mile}$
mm	$\begin{matrix} \swarrow 25.40 \\ \searrow 0.0394 \end{matrix}$	in.
m	$\begin{matrix} \swarrow 0.3048 \\ \searrow 3.281 \end{matrix}$	ft
m	$\begin{matrix} \swarrow 0.9144 \\ \searrow 1.094 \end{matrix}$	yd
km	$\begin{matrix} \swarrow 1.609 \\ \searrow 0.6214 \end{matrix}$	mile

AREA		
square millimeter (mm ²) square centimeter (cm ²) square meter (m ²) hectare (ha) square kilometer (km ²) $10^6 \text{ mm}^2 = 10^4 \text{ cm}^2 = 1 \text{ m}^2$ $10^6 \text{ m}^2 = 10^2 \text{ ha} = 1 \text{ km}^2$		square inch (in. ²) square foot (ft ²) square yard (yd ²) acre square mile (mile ²) $1296 \text{ in.}^2 = 9 \text{ ft}^2 = 1 \text{ yd}^2$ $3,097,600 \text{ yd}^2 = 640 \text{ acres} = 1 \text{ mile}^2$
cm ²	$\begin{matrix} \swarrow 6.452 \\ \searrow 0.1550 \end{matrix}$	in. ²
m ²	$\begin{matrix} \swarrow 0.0929 \\ \searrow 10.76 \end{matrix}$	ft ²
m ²	$\begin{matrix} \swarrow 0.8361 \\ \searrow 1.196 \end{matrix}$	yd ²
ha	$\begin{matrix} \swarrow 0.4047 \\ \searrow 2.471 \end{matrix}$	acre
km ²	$\begin{matrix} \swarrow 2.590 \\ \searrow 0.3861 \end{matrix}$	mile ²

SPEED		
meters/second (m/s) kilometers/hour (km/h) $1 \text{ m/s} = 3.6 \text{ km/h}$		feet/second (ft/s) miles/hour (mph) $88 \text{ ft/s} = 60 \text{ mph (exact)}$ $[1.467 \text{ ft/s} = 1 \text{ mph}]$
m/s	$\begin{matrix} \swarrow 0.3048 \\ \searrow 3.281 \end{matrix}$	ft/s
km/h	$\begin{matrix} \swarrow 1.609 \\ \searrow 0.6214 \end{matrix}$	mph

THE BUS TRANSIT SYSTEM: ITS UNDERUTILIZED POTENTIAL

Executive Summary

The bus system represents the most widely used transit mode. Upgraded bus services, primarily those which have partially or fully separated rights-of-way, represent a very cost-effective method to improve the balance between automobile and transit. Many measures for improving bus services were introduced since 1970. However, many of these improvements were not maintained: buses were gradually returned to operations in mixed traffic. The report examines the quality of bus services in various cities in North America and worldwide and analyzes the reasons for the phenomenon of “backsliding” or disappearance of bus transit priority measures.

In order to systematically evaluate bus services, they can be defined by their quality in a range between two “extremes”. Between these two “extremes” there are a number of partially upgraded bus transit services.

The **Basic Bus System (BBS)** consists of buses running on streets in mixed traffic without any special treatments. This system is adequate for small cities and lightly used lines, because it serves mostly captive riders.

Most medium and large cities need, in addition to BBS, high quality transit services, capable of attracting choice riders. High quality transit services, similar to rail systems (light rail, rapid transit and regional rail modes), can be provided by buses, but only if their operations are upgraded into the **Bus Transit Systems (BTS)**. The BTS is defined as bus service operating mostly on separated rights-of-way (bus lanes and busways), with extensive priorities for buses on streets, special stations, modern control systems, etc. BTS offers fast, reliable services on separate facilities with a strong image for the public. By far the best example of a BTS in North America is the transit system in Ottawa, Canada.

Two surveys were made: one questioned 14 selected transit agencies, the other obtained information and opinions from 24 bus transit experts about the conditions of bus services. Special focus was on the problem of implementing and maintaining their improvements. The survey answers confirm the basic hypothesis of this study: upgrading of bus systems is quite limited, particularly in U.S. cities. Most cities have only the BBS-type services. Thus, with the exceptions of Oslo, Ottawa and Pittsburgh, which have substantial bus transit facilities, the remaining 11 cities average only 1.1 km of bus lanes per city.

The reasons for this unsatisfactory state are inadequate funding, lack of ideas and initiatives by transit agencies, poor cooperation among transportation authorities and transit agencies, lax police enforcement, and traditional highway bias of many State Departments of Transportation. These are combined with pressures by automobile groups in lobbying for “improved utilization” of transit rights-of-way by opening up bus facilities to HOV's. The fact that this “improved utilization” leads to downgrading of bus services has been generally ignored.

Another factor that has prevented bus transit improvements is a lack of understanding of the role of transit and its significance in achieving more livable metropolitan areas. This lack of knowledge is found not only with the general public, but also with civic leaders and, sometimes, even by the transit agencies.

The report presents **fundamental principles for favoring transit over private automobiles**; briefly, they include:

Public services should be favored over private ones;

Transit vehicles provide much higher transporting capacity than automobiles;

Transit vehicles have far lower negative side-effects;

Transit priorities create a service which is competitive with auto use (they counteract the attractive image and emotional bias toward the automobile);

High quality transit is the key element allowing creation of a human-based city and livable urban environment.

The fact that buses are physically and operationally compatible with other highway vehicles should not prevent application of the above principles for favoring transit to the bus mode.

Giving buses facilities separated from other traffic results in improved quality of service, reliability, speed comparable to that of the automobile, enhanced image and permanence.

A special analysis was made of the presently very popular high occupancy vehicle (HOV) facilities. The initial creation of busways during the 1970s was very successful in several cities. However, under the pressure by the automobile lobbies nearly all busways in the United States have been converted into HOV facilities. The official policy of FHWA, and even of FTA, is to encourage construction of new HOV facilities. Actually, this is a typical example of transit priority backsliding.

A detailed analysis in this report shows that every conversion of a busway into an HOV facility results in relative downgrading of bus services and benefits to its competition. It also results in an increase in vehicle miles traveled (VMT) because introduction of new HOV lanes frees additional capacity for single occupancy vehicles (SOV's).

In a matrix showing busways and HOV facilities vs. the conversion of existing or addition of new lanes (see Fig. 5.3), by far the most effective solution is the "take-a-lane"/busway solution; the "add-a-lane"/HOV combination is the least desirable one, because it actually results in deterioration of bus services and an increase in VMT's because it encourages SOV usage.

Another problem is that most bus operations on HOV facilities represent peak-hour-only commuter services, used for many-to-one travel into CBD's, rather than regular, all-day transit serving the entire population for network-wide many-to-many points travel.

The report points out that the recent trend has been to introduce the "add-a-lane"/HOV, i.e., the least desirable form of priority facilities. The problems created by such facilities have been further aggravated by the lowering of the HOV definition to "2+" (any vehicle with 2 or more persons). This trend is directly counterproductive from the point of view of improving the total urban transportation system. It also directly contradicts the mandates in the Clean Air Act (CAA) and the Intermodal Surface Transportation Efficiency Act (ISTEA) that the use of SOV's should be discouraged. **The present policies of FHWA, and even FTA, encouraging HOV facilities in all forms, are clearly counterproductive and they should be revised to distinguish different types of these facilities and their impacts under each set of local conditions.** Each introduction or modification of HOV facilities should be subject to EIS analysis. Transit funds should be used only for exclusive bus facilities.

The main findings and recommendations of the report are summarized as 22 points in Chapter 6.

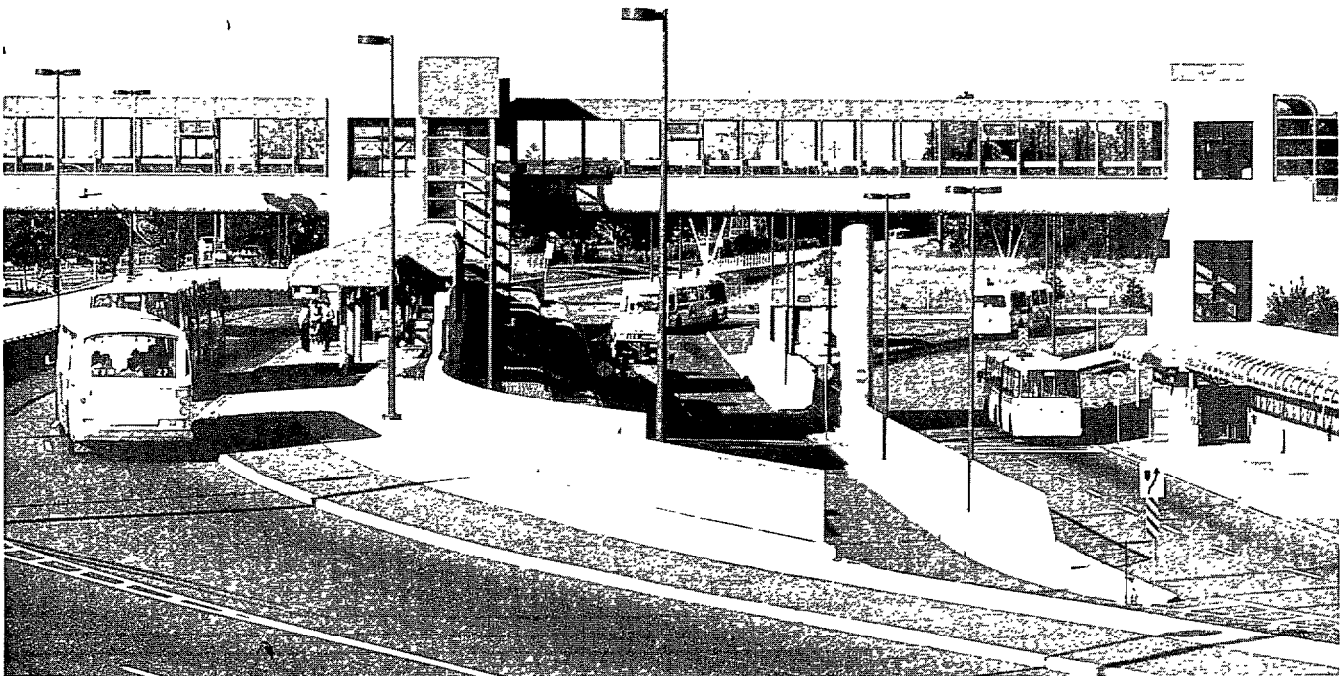


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Chapter 1

INTRODUCTION

Most metropolitan areas are faced with serious transportation problems, ranging from congestion and pollution to lack of mobility for certain population groups and excessive financial expenditures and energy consumption. Many cities analyze this problem and search for possible solutions to improve the present situation and develop a more efficient transportation system. They typically conclude that a set of measures is needed to achieve more efficient transportation, as well as enhanced quality of urban life. These measures include significant improvements of public transportation, encouragement of pedestrian and bicycle traffic, and coordination of land use with transportation systems.

The need for greater utilization of different modes and their better integration into coordinated systems has been recognized not only at local level, but also in national legislation: intermodal transportation is emphasized so strongly, that the current federal transportation act has it in its name: Inter-modal Surface Transportation Efficiency Act (popularly known as ISTEA).

Achieving a modern and efficient transit system, however, is not a simple task. Selection of transit mode and design of individual facilities are crucial in reaching an optimal solution in a given city or area.

While rail transit clearly provides an attractive, environmentally friendly transit system which offers high level of service, it is feasible only in major corridors where high ridership justifies its high investment. Improvements of bus services have a much lower “threshold” in terms of ridership volume and therefore present a great potential for improved transit in a much greater number of cities.

Bus systems are operated in all cities which have transit services: they are practically ubiquitous. While lightly used bus lines do not justify investments and efforts for improved operations and priorities for transit, there are numerous cases of heavily travelled bus lines where improved bus operations are needed.

Potential for major improvements of bus services mostly exists in medium-sized and in all large cities. Even in cities which have extensive rail services, bus feeders and complementary network are of great importance. No rail system can use its full potential without extensive bus

feeders and other complementary services.

1.1 The Problem: Neglect and Downgrading of Bus Services

Although many bus service improvements require only limited changes in infrastructure and moderate investments, they are usually difficult to implement. Physical constraints in the streets and on freeways represent one obstacle; lack of adequate funding may also be a problem. However, in most cases the obstacles to improvements are not physical or financial, but human and organizational: low technical competence and lack of expertise, lack of support or direct opposition by different agencies, difficulties of coordination, pressures by automobile/highway interests, opposition to changes by local store owners, etc.

In many cases even successful implementation of bus improvements is not a guarantee for permanent success. Some of them are gradually neglected, modified or abandoned, and bus service degrades to the basic one where bus operates simply as “just another vehicle” on urban streets, subjected to delays and uncertainty of general street traffic.

With the increasing interest in upgrading transit in our cities during the early 1970s, it became obvious that there was a large “gap” in the cost-performance “packages” between buses on streets and rail rapid transit systems. Most cities were missing the systems which would be between these two extremes: offer much better service than buses on streets, but require much lower investment than rail rapid transit.

A series of innovations in transit systems design, technology and operations led to activities which began to successfully close this “gap” from both sides: major improvements of bus services from the “lower side” of the gap, and introduction of light rail transit, representing lower-investment rail systems, from the “upper side”.

In planning to upgrade bus services, it was realized that the improvement measures should consist not only of better vehicle designs and building of more shelters, but that the most important element bus services must have in order to offer higher speed and reliability of service is independence from general traffic and street congestion. That can be achieved only when buses (similar to light rail transit) are provided with separate rights-of-way, stations and related infrastructure. The higher speed and quality of service they have on such facilities make them competitive with auto traffic. They tend to compensate for bus delays caused by their stopping

to board and alight passengers.

Construction of several busways (Shirley in Washington, El Monte in Los Angeles, several in Pittsburgh and Ottawa), contraflow lanes on I-495 on the New Jersey approach to Lincoln Tunnel and on California Highway 101 in San Francisco/Marin County, numerous bus lanes and malls in city centers, were examples of major improvements and creation of distinct bus systems competitive with automobiles.

Subsequently, however, degradation of many of these facilities occurred. Most of these exclusive bus facilities were converted into facilities shared with progressively greater number of other vehicle categories, i.e., into HOV facilities with vans and then even with passenger cars with decreasing minimum occupancies; in a few cases, exclusive lanes have been even converted into “general purpose” lanes. This has created a situation that practically eliminates buses as a viable alternative for a distinctive transit system which is competitive with private automobiles and car-pools. The situation has become such that to achieve such systems, cities must build rail systems whose rights-of-way cannot be physically degraded into “general purpose” like busways and bus lanes. This is a very serious problem.

1.2 Purpose and Scope of the Study

The main objectives of this study are to:

1. Clearly define an upgraded bus transit system;
2. Find out and evaluate present condition of bus services with respect to their upgrading from the simple service in mixed traffic in urban streets;
3. Define the reasons why and under what conditions bus service improvements should be introduced;
4. Define the obstacles commonly encountered in implementing and in maintaining measures of upgrading bus services;
5. Recommend policies and actions which would overcome these obstacles and allow development of bus systems which have considerably higher level of efficiency, passenger attraction and positive impact on urban quality of life.

1.3 Study Methodology

The concept of **the Bus Transit System (BTS)** and the elements which that system must have were first defined. Then, surveys of leading transit operators and of bus transit experts were made. The surveys collected information about present conditions of bus services and the experts' explanations, evaluations and opinions about the conditions of bus services, focusing on various aspects of their upgrading - successes and failures.

Evaluation of the survey results was then made and the obstacles to bus transit improvements and to their permanent maintenance were summarized. A set of arguments and justifications for giving transit priorities, particularly separate rights-of-way, have been developed. Recommendations for policies and technical measures to implement and maintain bus transit systems are given.



Chapter 2

THE RANGE OF BUS SERVICES

Every bus service can be described and evaluated by its characteristics, such as performance, quality of service, investment and operating costs, image, etc. This set of characteristics will be referred to here as “performance-cost package”. If different bus services in North American cities are grouped and classified by their performance-cost packages, they can be placed into a range from the simplest, lowest quality system, which will be designated as the basic bus system or BBS, to the highest quality system with high performance and distinct image, which will be referred to as the Bus Transit System or BTS.

In this chapter these two types of systems, BBS and BTS, are defined, and their elements and characteristics are discussed.

2.1 The “Basic Bus Service” - BBS

By far the most common bus service in most cities consists of buses operating on urban streets in mixed traffic and stopping at locations marked by bus stop signs, sometimes with shelters, and, exceptionally, with information about route alignment and schedule.

While quality of buses, organization and reliability of their services may vary with street traffic conditions and management characteristics, a common feature for these services is that they have virtually no special infrastructure. They utilize urban streets, but they have no exclusive lanes or signal priorities, no off-street facilities, or sometimes, even no distinct facilities at bus stops.

In central areas of many cities the basic bus service is virtually ubiquitous. Its great advantage is that it can be introduced without much investment in a very short period of time. Also, it can be modified in alignment, extended or closed without major investment or losses (although any changes are usually subject to public hearings). On the other hand, the absence of any special infrastructure is also a great liability of the basic bus service. Without any infrastructure this service has no permanence, no distinct image and its performance is generally inferior to that of the private automobile. In other words, the BBS cannot be considered as a distinct, integrated transit system.

Consequently, the vast majority of the bus service ridership are captive transit riders. Thus, any city that wants to attract some trips from the private automobile to transit must provide services substantially superior to those that the basic system can offer.

It is a major problem that even in our largest cities, such as New York, Philadelphia and San Francisco, all services provided by buses represent BBS. In spite of their vital importance for these cities, buses enjoy no priorities over the private automobiles. This situation shows the great importance of the problem analyzed in this report.

2.2 The “Bus Transit System” - BTS

The other extreme in the range of bus transit system performance is the one which has extensive special infrastructure separated from that for general traffic. In this system, buses operate on exclusive busways or separate lanes and they enjoy priority treatment at signals and intersections. They may have elaborate stations with convenient transfers among bus lines and between buses and other modes, fare collection, waiting rooms, information and other facilities.

Because of the special infrastructure, bus transit system requires considerable investment. Once the investment into such a permanent system is made, it is logical that higher quality buses should be used and that the system should have high quality control of operations. Such a high performance and attractive service with physical permanence would have a stronger image than the basic bus service. Hence, it would attract a much greater ridership.

In addition to the high quality service on individual lines, BTS has integrated services on different routes intramodally, as well as intermodally, i.e., bus lines operate with convenient transfers to other modes, such as rail transit and long distance bus, rail and air terminals.

As mentioned in Chapter 1, the necessity to upgrade transit systems in North American cities was recognized in the early 1970s. Under UMTA’s initiatives, many new technical and operational concepts were developed. A number of innovations were aimed at “filling the gap” between BBS and large scale regional rapid transit systems, such as BART. Light rail transit was introduced as one new concept. Another concept was major upgrading of bus transit services. It became obvious that building of a bus transit system would be the logical, most cost-effective solution in the corridors with moderate or large passenger volumes where considerably higher level of service is needed, but the investment rail transit would require is not available.

During the early 1970s several bus transit facilities and high quality systems were built. For example, major improvements in bus services and construction of exclusive busways were effected in Washington, DC (Shirley Busway), Los Angeles (El Monte Busway and numerous exclusive bus lanes) and Pittsburgh (two busways). However, most of these bus improvements had to overcome very strong opposition, not only from various local merchants and other interests, but sometimes also from city traffic departments and state highway (transportation) departments.

Organizational difficulties, inadequate financing and strong pressures by highway lobbies in many cities resulted in eventual “backsliding” - gradual discontinuance of bus priorities and downgrading of most bus facilities. For example, control and enforcement of exclusive bus lanes have been relaxed in many cities, making these facilities ineffective. Special transit priority signals were either stopped before implementation, or made ineffective by inadequate maintenance.

The most drastic degradation of bus transit services was done with the introduction of the concept of high occupancy vehicle (HOV) lanes and roadways. While the concept of HOV is virtually unknown in other countries, nearly all busway facilities in the United States have been downgraded into HOV facilities. A systematic review of and evaluation of the HOV concept is given in Chapter 5. It should only be mentioned here that with the introduction of HOV virtually all bus transit systems in our cities have suffered from the drastic loss of their image. Today no U.S. city has a bus transit system of the quality comparable to the bus systems found in Ottawa (Canada), Curitiba and Sao Paulo (Brazil), and Wiesbaden (Germany).

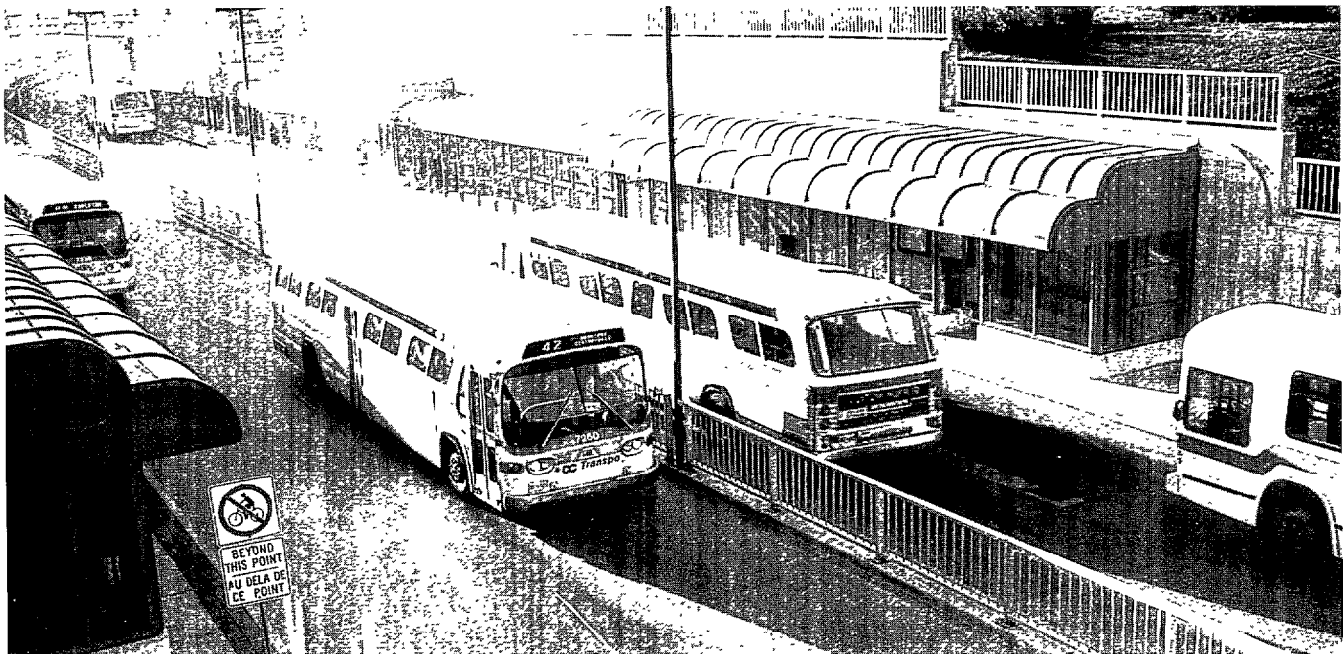
2.3 Classification of Upgraded Elements

To review and evaluate bus transit in different cities, it is useful to classify its characteristics which should be upgraded to achieve a high quality bus transit system. While the elements which can be considered may be elaborated into a long list varying from mechanical features of buses to network integration, the focus in this study is on infrastructure and organizational elements, many of which are not under full control of the transit agency. Their upgrading can be achieved only with cooperation of the city and state authorities and various other organizations and groups.

The bus system elements are therefore classified into six categories as follows:

1. Travel way preferential treatment
 - Preferential treatments on streets and arterials
 - Preferential treatments on freeways
 - Busways
2. Bus stops and stations
3. Vehicle performance
 - Bus body - passenger section
 - Technological advances in urban bus design
4. Operations and control
 - Operational center with computerized control
 - The fare system
5. Level of service: speed, reliability, comfort, etc.
6. Marketing and public information.

As mentioned above, the focus in this study is on the elements which depend not only on the transit agency, but also on other organizations, bodies and groups; these are primarily travel way, bus stops, operations and control, and level of service (influencing the image and the role of bus transit in the family of urban transportation modes).



Chapter 3

THE PRESENT BUS SERVICES: SURVEYS AND THEIR FINDINGS

The vast majority of bus transit systems in U.S. cities represent the basic bus services: they consist of buses running on public streets without any separation from other traffic. In many cities transit stops are located at every corner, unchanged from the horse-drawn omnibuses over 100 years ago, and buses stop at them on demand. The infrastructure for buses typically consists of bus stop signs, sometimes passenger shelters, and very little else.

While this service is adequate for small cities and towns, medium and large cities desperately need higher quality transit services which can be provided only by separate infrastructure and preferential treatments for buses.

During the last 20 years, there have been numerous suggestions and implementations of bus system improvements in many U.S. cities. Yet, few of these improvements are in successful operation at present. Many of the planned upgrading measures were never implemented, while some others were implemented and later discontinued or modified, so that much of their effectiveness has been lost.

3.1 Purpose and Description of the Surveys

To obtain information about the deterioration of bus systems services and facilities, and to evaluate the present conditions of bus systems, two surveys utilizing written questionnaires were undertaken in this project. The main purposes for these surveys were to obtain information about specific bus transit priorities in a number of major North American and selected overseas cities; to gather opinions of transit operators about the activities for upgrading bus services; and, to obtain their explanations about the obstacles to the introduction of improvements and causes for later abandonment in some cases.

Particular focus has been placed on the reasons for the “backsliding” in bus transit system performance and service quality due to reductions or withdrawal of preferential treatments. The best examples of such “backsliding” of bus services in many U.S. cities since 1970s have been cases of discontinued exclusive bus lanes on streets and the conversions of busways first into HOV facilities, and then from allowing passenger cars with at least 4 passengers (“4+”) into HOV

lanes to reducing that minimum occupancy to 3 (“3+”), and finally, into “2+” facilities. This process has led to progressive downgrading of bus services in many cities.

In parallel, another survey covered a number of selected transit experts with particular experience in bus transit system services in many cities. While the first survey was intended to provide a “view from the front line”, this second group was used to bring the perspective and comparison of bus services in different cities.

The two questionnaires were developed very carefully. Attention was given to their contents and phrasing of questions; clear responses were stimulated through attractive physical layout; opportunities to express opinion and submit additional information were provided.

The first questionnaire, for transit agencies, was titled “Upgrading of Bus Transit Services.” This questionnaire and a list of transit agencies which answered it, are presented, respectively, as Sections 1 and 2 in the Appendix. The questionnaire encompasses the following nine major aspects of bus transit systems:

1. Right-of-way improvements introduced in the last 10-15 years
2. Stop and station improvements
3. Priorities at intersections
4. Improvements in operations
5. Improved enforcement by police and transit officers
6. Integration of bus lines
7. Public information and marketing
8. Transit system development policy and strategy
9. Suggested further improvements.

This questionnaire was sent to 20 U.S., Canadian and European transit agencies, selected as those with most activities in upgrading their bus systems. Fourteen agencies (70.0%) responded to this survey.

The second questionnaire, on Upgrading Bus Transit Systems, was prepared for bus transit experts and sent to 31 selected individuals in several countries: United States, Canada, Mexico, Germany, France, Norway, Brazil and Japan. This second questionnaire and the list of the 24 persons who responded (77.4%) are given, respectively, as Sections 3 and 5 in the Appendix.

The questionnaire for transit experts consists of seven questions about the following four

subjects:

1. Importance and effectiveness of different improvement measures and their results;
2. Obstacles to introduction of bus system improvements;
3. Reasons for the backsliding of improvements in time; and
4. Actions needed to facilitate implementation and permanence of improvements.

In addition, opinions of experts were solicited with respect to the achievement of different cities in upgrading their bus services. Their general comments on the subject were also solicited.

3.2 Results of the Surveys

The answers to the two questionnaires have been analyzed, tabulated and plotted in a series of charts and tables. They are presented and discussed, collectively by individual features, in this section. Interesting features of bus systems in individual cities are highlighted in the discussions.

3.2.1 The Present Conditions: Responses of Transit Agencies

The results of the responses are summarized in Table 3.1; some results are plotted in bar-charts in Figures 3.1 and 3.2; and, finally, a brief summary of the most important information about each city of the 14 transit agencies which responded to the questionnaire is given in the Appendix 5.

Table 3.1 contains the responses to the basic element of transit priorities - right-of-way (R/W) separations of buses. The table is divided into three sets of columns: special lanes on streets, on exclusive streets and roadways, and on freeways.

The numbers in the table show that most cities have extremely limited lengths of bus or HOV lanes on city streets; except for San Francisco, Seattle and Oslo, none of the cities has more than 10 km of these facilities. For cities as large as Los Angeles, Washington, and Houston, this size of facilities is virtually negligible. This condition shows the underlying problem of low quality bus transit services in U.S. cities: no transit network can effectively compete with the private automobile in speed and reliability, unless it has largely separated rights-of-way. Separation from general traffic is also necessary for a distinct image which transit must have in order to attract a reasonable share of choice riders. Our bus systems do not have this basic feature for high quality service.

Table 3.1 Summary of the R/W improvements for the 14 cities participants in the survey

Transit agency	Bus/HOV lanes on streets					Exclusive bus/HOV streets, roadways, malls				Bus/HOV lanes on freeways				
	No.	Length [km]	Usage	Place-ment	Direction	No.	Length [km]	Usage	Type of facility	No.	Length [km]	Usage	Place-ment	Direction
Calgary, CALTRANS	1	0.6	bus only -discon'd	curb	withflow	1	2	bus+LRT	mall	/	/	/	/	/
Chicago, CTA	6	5.5	bus only	curb	withflow reversib.	1	1.8	bus+taxi	mall	/	/	/	/	/
Denver, RTD	2	9.6	bus only discon'd	curb	withflow	1	3.2	bus only	mall	1	6.4	bus only	median	withflow
Hartford CTT	10	0.8	bus only	curb	withflow	/	/	/	/	1	19.2	HOV 3+	median	withflow
Houston METRO	5	8	bus only	curb	withflow	/	/	/	/	6	152.8	HOV 2+	median	reversible
Los Angeles, RTD	1	0.8	bus only	curb	contraflow	/	/	/	/	2	70.4	HOV 3+	median	withflow
Newark, NJT	3	8	bus only	curb	withflow	/	/	/	/	1	6.4	bus only	left	contraflow
Oslo, Norway	12	35	bus only and bus + taxi only	curb, median	withflow	2	6	bus only	busway	2	8	bus + taxi	right	withflow
Ottawa, OC Transpo	1	3	peak, bus only	curb	withflow	1	25	bus only	busway	1	8	peak, bus only	curb	withflow
	1	2.5	all day, bus only	second lane	withflow	1	0.4	bus+taxi	mall	1	7.5	peak, bus only	curb	withflow
	1	3.8	peak direction	curb	withflow	1	0.4	bus only-discon'd	mall			peak, bus only-discon'd		
			HOV 3+			1	0.7	bus only	busway					
Pittsburgh, PATransit	4	4.5	bus only	curb	contraflow	2	17.3	bus only	busway	1	6.4	HOV 3+	median	reversible
San Antonio, VIA	6	4.3	bus only	curb	withflow	/	/	/	/	/	/	/	/	/
San Francisco, MUNI	11	19	bus+taxi, all day	curb	withflow	/	/	/	/	/	/	/	/	/
Seattle, METRO	8	11.7	bus only and HOV	curb	withflow contraflow	2	5	bus only	busway	20	84.9	HOV 3+ HOV 2+	curb median	withflow withflow
Washington, WMATA	/	/	/	/	/	/	/	/	/	2	27.4	HOV 3+	median	withflow

Survey of 14 transit agencies

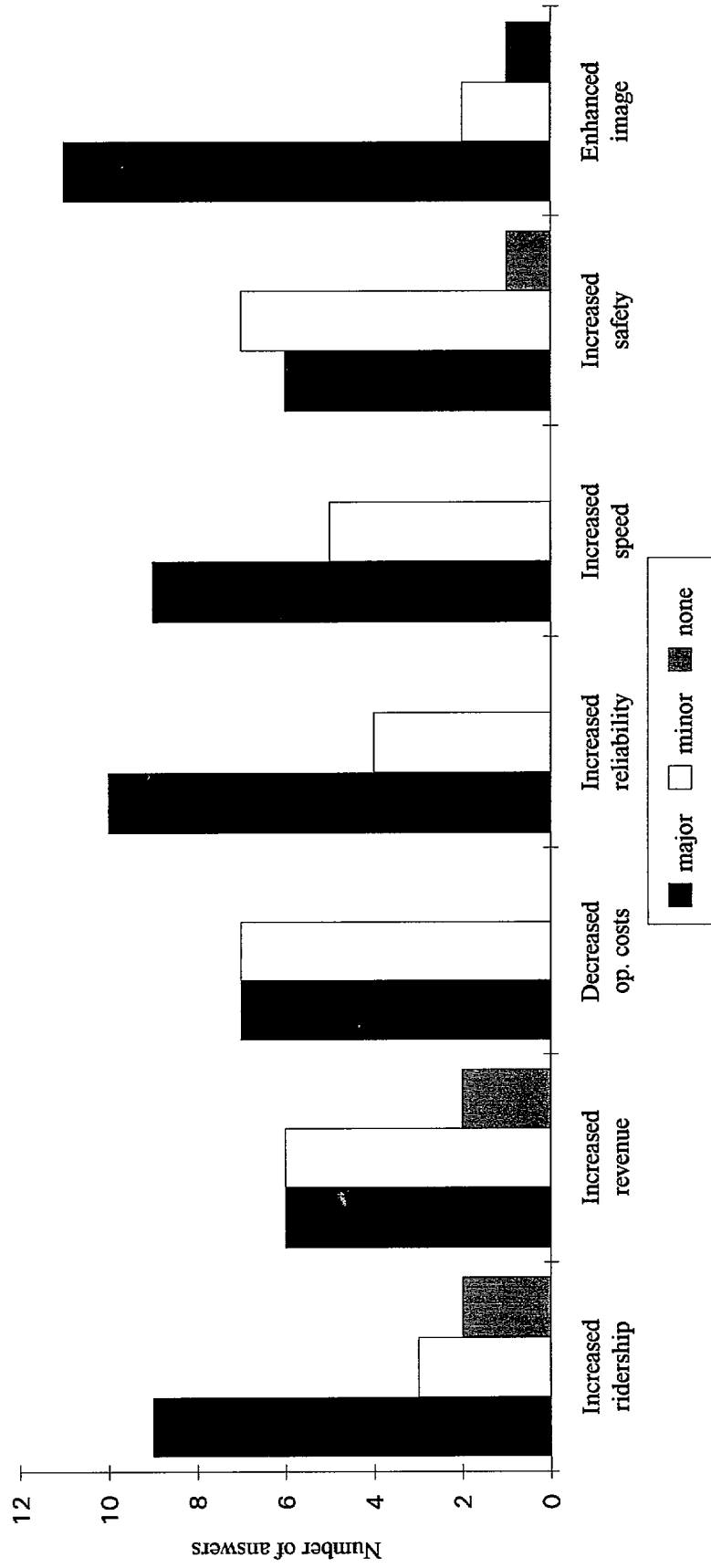


Figure 3.1 Evaluation of the results of the right-of-way improvements (Question 1.4)

Survey of 14 transit agencies

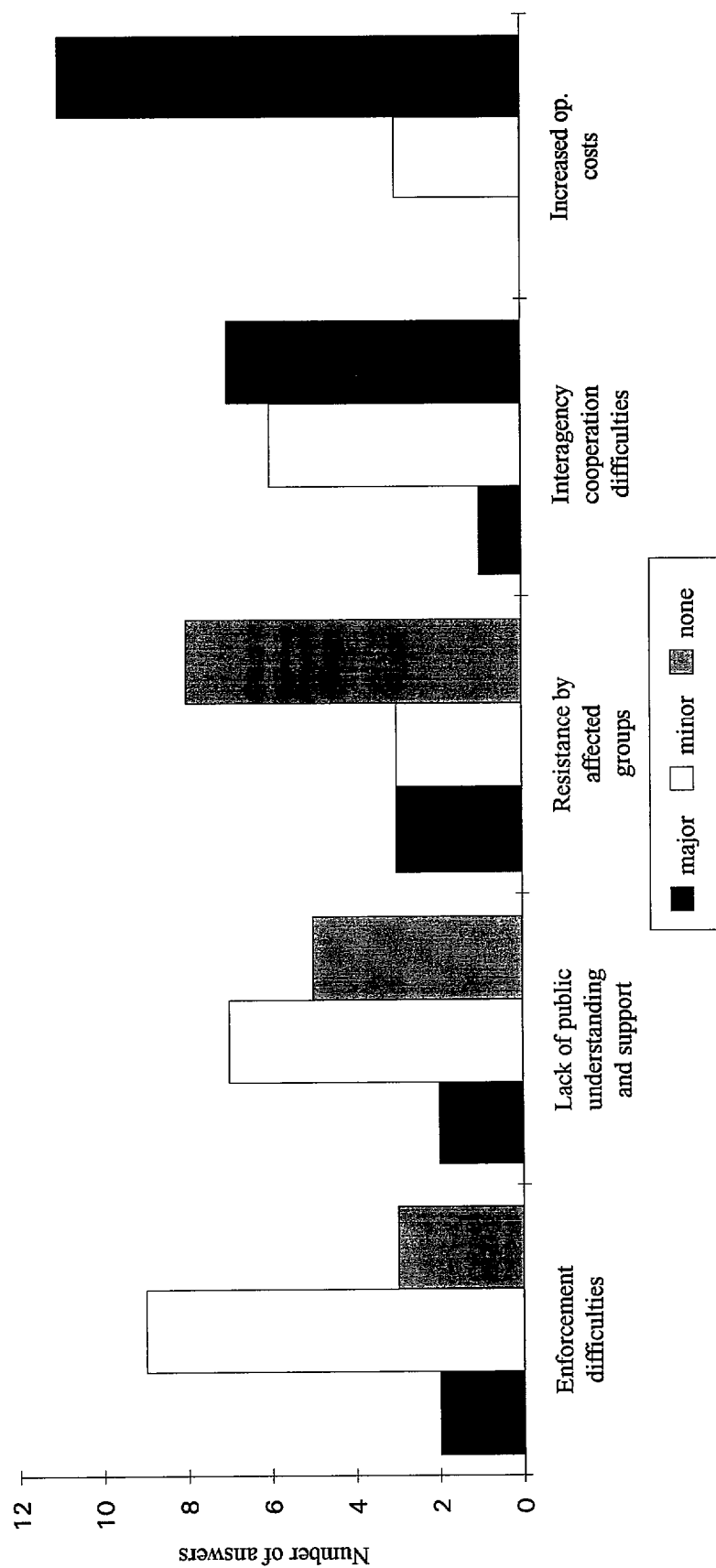


Figure 3.2 Negative results and problems (Question 1.4)

Exclusive streets for buses or HOVs are even more limited, the total for the 14 cities being only 61.8 km. However, since 49.8 km of these 61.8 km are found in only three cities - Ottawa, Pittsburgh and Oslo - upgraded right-of-way sections in the remaining cities are obviously extremely short (12 km for 11 cities), averaging only 1.1 km, or less than one mile per city.

The length of bus/HOV lanes on freeways is considerably greater, amounting to a total of 397.4 km, but the distribution of these lanes among cities is again very uneven: 308.1 of the 397.4 km (77.5%) are located in Houston, Seattle and Los Angeles. Even these impressive lengths of facilities in Houston and Seattle are deceptive, because most of them are of the lowest quality: they are part-time, one-way HOV 2+ facilities. It should be pointed out that many of these facilities have been downgraded from busways (El Monte in Los Angeles) or 4+ lanes to 3+, and then to the lowest category, 2+ HOV facilities.

Since each one of these changes reduces the benefits buses have and encourages their competition - private automobiles - this trend clearly illustrates widespread attitudes of neglect of bus transit and caving in to the automobile lobby interests under the claim that the spaces or “gaps” between buses on exclusive lanes can be filled with automobiles without any adverse impact to the buses. This claim, known as the “filling the gaps in lanes” syndrome, is false because it neglects the fact that increasing vehicular volumes decrease the level of service. Moreover, mixing of automobiles greatly diminishes the image of transit service on separate rights-of-way and practically destroys the **Bus Transit System** concept. The downgrading of facilities and other bus priorities is known as the phenomenon of “backsliding”.

It should be mentioned that buses are generally given a more distinct priority on urban streets designated for buses only than on freeway facilities. Actually, only two cities reported having exclusive busways on freeways.

By far the best system of bus right-of-way priorities is found in Ottawa which has, with one exception, only exclusive bus facilities, not HOV lanes and roadways. The most extensive system of HOV facilities exists in Houston, but it consists, as mentioned above, nearly exclusively of reversible freeway lanes for HOV 2+ It is therefore a system that caters primarily to the commuter traffic and has the lowest possible distinction of transit services as compared to their main competitor, the private automobile. The alignment and elements of this and other

HOV facilities were designed primarily for automobile traffic; buses were then added to the given freeway alignment.

Most important opinions expressed in the questionnaire by the transit operators are presented as bar-charts in Figures 3.1 and 3.2. Among the results of the right-of-way improvements, transit operators ranked first the enhanced image (11 out of 14), followed by improved reliability and increased ridership (the latter being a consequence of most other improvements, such as speed and safety increases). About half of the responding agencies quoted increased revenue and decreased operating costs as the major results of right-of-way improvements (6 and 7 transit agencies, respectively).

A number of responding agencies stated that enforcement difficulties, poor public understanding, and inadequate cooperation among government agencies were the major barriers to improvements. Resistance by affected groups was quoted as the problem by six agencies, while most other agencies had no problems with organized opposition. Most agencies did not incur increases in operating costs; actually, as mentioned above, 7 of the 14 respondents reported major decreases in costs as a result of the preferential treatments.

A descriptive summary of the answers by individual agencies is given in Appendix 5.

3.2.2 Analysis of the Present Conditions: Responses of Transit Experts

Figure 3.3 shows how transit experts evaluated different criteria for bus service improvements. Among these criteria, increased reliability and higher speeds were evaluated as the most important factors (21 out of 24 answers). These elements were followed by increased ridership and improved image, which were considered as being of major importance by, respectively, 14 and 13 out of 24 respondents. Decreased operating cost was mentioned as the major factor by only 8 respondents, while 15 respondents considered it as a minor criterion for evaluating bus service improvements. Higher safety was considered the least important among all the factors: only one respondent considered it of major importance, while 15 gave it a minor importance and 8 considered it unimportant.

Figure 3.4 shows the evaluation of the effectiveness of different types of right-of-way separation. Exclusive busway was, logically, given the highest rating, with 17 out of 24 respondents considering it as being of high importance. This was followed by exclusive bus lanes on streets with 12 out of 24 “high” and 11 “medium” ratings. Only one person gave exclusive

Survey of 24 transit experts

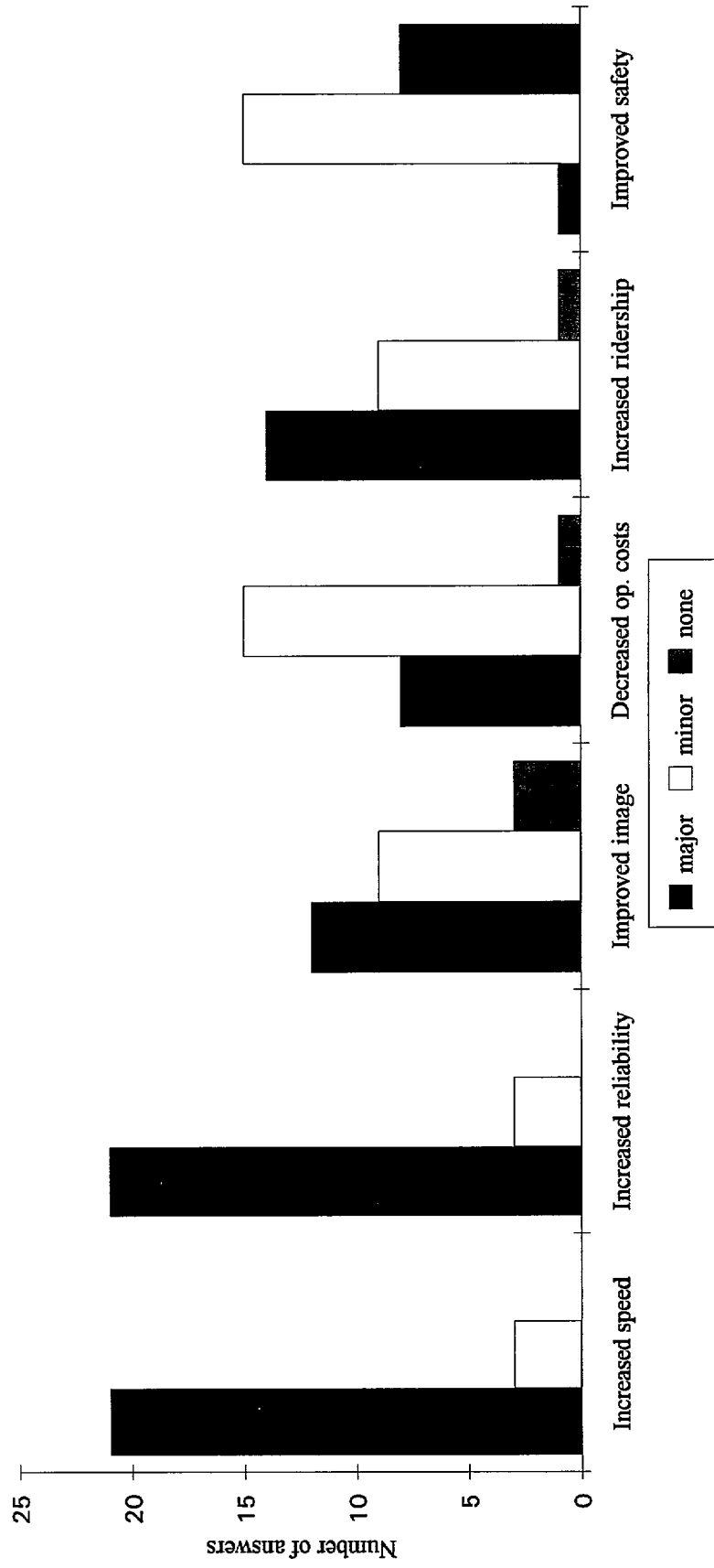


Figure 3.3 Evaluation of the importance of different criteria for bus service improvements (Question 1)

Survey of 24 transit experts

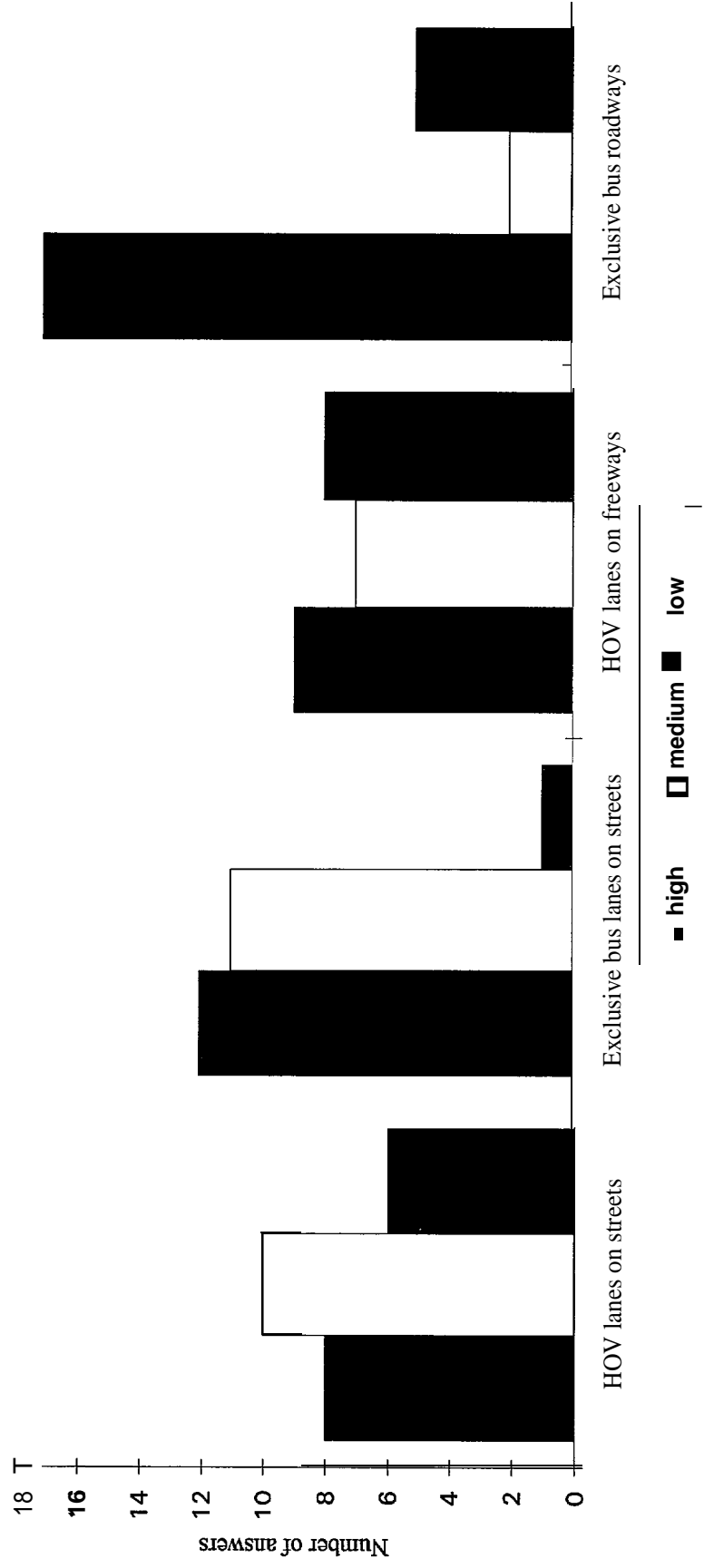


Figure 3.4 Evaluation of the effectiveness of different types of right-of-way separation (Question 2 a)

bus lanes on streets low effectiveness rating.

Figure 3.5 presents evaluations of the effectiveness of all measures and factors for bus service improvements except for upgrading of right-of-way. The experts have evaluated individual measures as follows:

Modernization of stops and stations was considered by most experts (16 out of 24) of medium importance. Six of the respondents gave this measure high importance, while two considered that it has low significance.

Bus priorities at intersections was given high and medium importance by a total of 19 out of 24 respondents, while five of them considered it of little importance.

Operations control was given high importance by 11 of the respondents and medium importance by nine of them.

Enforcement of traffic regulations was given a similar rating; 12 out of 24 experts gave it high importance, nine considered it of medium importance and only three gave it low importance.

Intra- and inter-modal integration of bus networks obtained the highest ranking. While 11 out of the 24 respondents gave it high and 13 medium importance, no respondents considered it to be unimportant.

Information and marketing with nine respondents giving it high or medium importance, is rated slightly lower than the preceding measures.

Transit system policy which supports transit priorities obtained a slightly higher rating, with ten “high” and 10 “medium” importance evaluations.

Reviewing Figures 3.4 and 3.5, it is quite apparent that most respondents considered that several different measures should be introduced together. With the exclusive bus roadways having the highest percent of “high importance” rating (17 out of 24 or 70.8%), each one of the seven other measures, plotted in Figure 3.5, obtained a total of more than **75%** (or more than 18 out of 24) high or medium ratings.

The summary of the reasons for deterioration of bus services and backsliding of their improvements, presented in Table 3.2, shows that many different reasons were given by the respondents. However, two groups dominate. The first group consists of two items which are mostly the responsibilities of transit agencies. These are the first item in the table, failure to

Survey of 24 transit experts

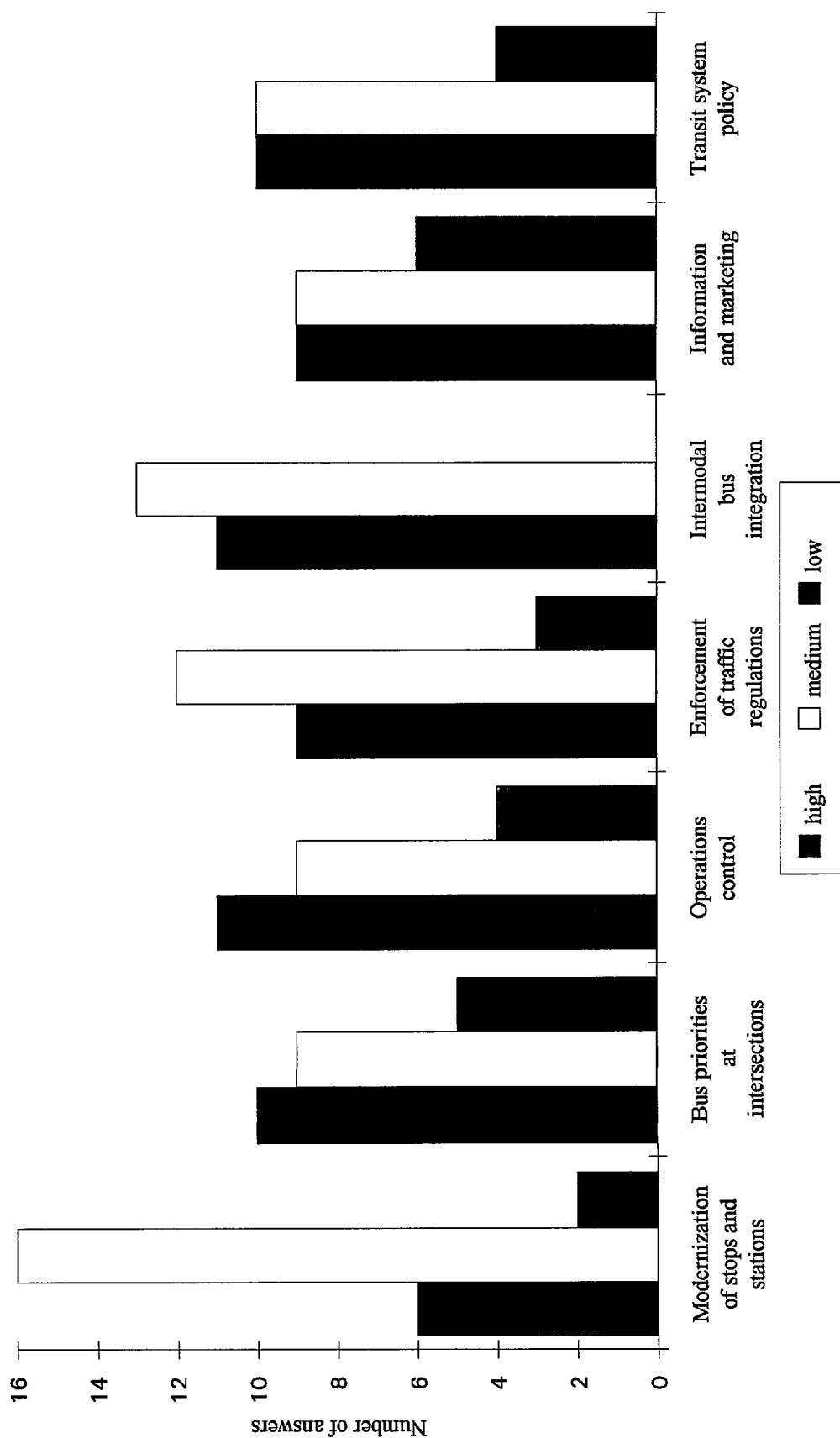


Figure 3.5 Evaluation of the effectiveness of different types of bus service improvements (Question 2 b)

Table 3.2 Summary of the reasons for bus improvements deterioration (Question 4)

No.	What are the reasons that bus service improvement sometimes deteriorate in time?	Frequency of answers
1	Standards of operation are not maintained through management control, decreased attention from transit management (other priorities)	11
2	Lack of enforcement	5
3	External market changes	5
4	Increasing congestion	4
5	Drop in subsidy funds	4
6	Inadequate information and marketing	4
7	The infrastructure is not maintained to higher standards	3
8	Lack of public consensus on the importance of bus service and decrease of private car use	2
9	Lack of post-facto evaluation. Most improvements must be fine-tuned after implementation.	2
10	Deterioration of vehicles. Inadequate maintenance.	2
11	Inadequate fares	2
12	Lack of expected patronage	1
13	Continuous political and administrative changes	1
14	High rotation of technical personnel that does not give a continuity to programs an actions taken	1
15	Decline in quality of service	1
16	Lack of standards and well established rules	1
17	Lack of well prepared technical personnel	1

maintain operating standards, and the sixth item, inadequate information and marketing of transit services. These items were quoted by respondents 15 times. The second group of causes, consisting of items 2-5 and 7, which totaled 21 quotes, is not under transit agencies' control domain. This considerable number of quotes indicates the failures of the city's government, poor understanding by the population and by political leaders of transit problems, and of the importance of transit services for the city.

Among the changes considered most important for introduction and maintenance of bus priorities, listed in Table 3.3, the experts give predominantly (19 out of the total of 40 quotes) three items which are mostly in the domain of public education, attitudes and policies: (1) Adequate financing; (2) Better understanding of the importance of transit; and (3) Improved transportation policies of the federal, state and local governments. The first item, adequate financing, is actually a result of the second and third items, broader understanding of the problems and improved government policies.

Table 3.4 lists the experts' quotes of successful bus upgrading cases. The results in the table show that the publicity of upgraded bus systems does not always correspond to their objective values. While the top six most frequently mentioned cities have made significant progress in improving bus services, their sequence is not logical. Houston, the first on the list, actually has a commuter bus system considerably inferior by its quality and success to the bus systems in Ottawa, Pittsburgh and Curitiba. Moreover, Portland and Sao Paulo have bus systems of much higher quality than many of the systems listed above them in the table.

A very interesting item, central to this project, is the phenomenon of discontinuing of bus priorities or backsliding, mentioned in the preceding section. The answers about such cases are listed in Table 3.5, but the information given on these cases is rather limited. The answers were therefore supplemented by other sources of information about these and other cities in which backsliding has taken place.

A case that requires a special mention here is Tyne and Wear (City of Newcastle) in Great Britain. Having introduced a highly successful fully integrated light rail-bus system in mid-1980s, this city had to abandon it because multimodal transit agencies have been legally banned in Great Britain (!). This British legislation represents by far the most short-sighted and destructive public policy toward urban transit in any developed country.

Table 3.3 Summary of the importance of the changes needed (Question 5)

No.	In your opinion, which are the most important changes which would facilitate implementation of bus service improvements and ensure their permanence?	Frequency of answers
1	Adequate finance for implementation	8
2	Better understanding of the benefits of bus service improvements	6
3	Appropriate central and local government policies	5
4	Promotion and good management practice	3
5	Better market demand information to identify where demand could benefit from an improvement	3
6	Better coordination between agencies	3
7	Better land-use policies	2
8	Special bus right-of-way	1
9	Eliminate redundant stops	1
10	Rationalization of route structure	1
11	Better enforcement	1
12	Better sharing and dissemination of “success” among transit agencies	1
13	Adequate fare system	1
14	Definition of lasting energy policy	1
15	Improved image of the bus system (low-floor, electric power)	1
16	Improved planning policy in transit agencies	1
17	Ongoing maintenance	1

Table 3.4 Summary of the mentioned successful bus upgrading examples (Question 6a)

City	No. of times mentioned	Reason (where given)
Houston	6	Introduction of express transit service, improved reliability, park & ride
Ottawa, Canada	5	Busways, excellent feeder system, park & ride
Seattle	3	Improved downtown circulation, express service, dual power buses
Pittsburgh	2	Busway system
Curitiba, Brazil	2	Busway system, use of paid-area bus stations/stops
Ziirich, Switzerland	2	
New Jersey I-495	2	Contra-flow bus lane
Lubeck, Germany	2	
Portland	1	Timed-transfer system
Sao Paulo, Brazil	1	EMTU's busway system in the industrial sector of Sao Paulo
Oslo, Norway	1	Low-floor articulated buses
Gothenburg , Sweden	1	Express service coupled with timed-transfer feeder bus services
Luxembourg, Luxembourg	1	
Toronto, Canada	1	
Vancouver, Canada	1	Timed-transfer system, integrated simple fare
New York	1	
Philadelphia	1	
Nagoya, Japan	1	Contra-flow bus lane
Tokyo, Japan	1	Information and control system, route deviation system (Demand Bus System) provided by Tokyo Bus Co.
Kanazawa City, Japan	1	Park & ride
Washington	1	I-95 HOV lane
Guadalajara, Mexico	1	
Wiesbaden, Germany	1	

Table 3.5 Summary of bus upgrading examples that later have been discontinued (Question 6b)

City	No. of times mentioned	Reason (where given)
Mexico City, Mexico	2	In 1984 there was an attempt to introduce well-developed bus maintenance system that was never implemented due to opposition by the labor. Attempts to improve the information system and bus scheduling have failed.
Atlanta		Downtown bus lanes discontinued
Belo Horizonte, Brazil	1	Trolleybus busway discontinued
Bergen, Norway	1	Discontinued bus lanes
Boston	1	SE Expressway bus lanes discontinued
Chicago	1	Contraflow bus lane discontinued
Hamburg, Germany	1	
Montreal, Canada	1	
Oakland	1	A number of neighborhood routes discontinued because of lack of patronage - insufficient subsidy funds
Tyne and Wear, Great Britain	1	Integrated network discontinued because of change of the national policy
New Jersey	1	Garden State Parkway bus lane discontinued

Supplementing the answers in Tables 3.2 to 3.5, Table 3.6 gives a summary of specific answers and comments given by the respondents. These comments clearly show that the respondents consider upgrading of bus to be a system problem. In other words, bus service must be treated not simply as a different type of vehicle operating in mixed traffic; rather, bus service should be carefully planned and operated as a distinctive transit system: it should be given as much priority and independence from congestion on streets and highways as local conditions allow.

To upgrade a basic bus service into a bus transit system, there should be a consistent policy which gives the priority to transit services and ensures proper implementation and enforcement of these measures. From the transit agency's side, it is required that operations be reliable, lines integrated in a network with convenient transfers, and the entire service be presented to the public through extensive information and marketing.

3.3 Obstacles to Bus Service Upgrading

The critical question in analyzing the reasons for the very limited applications of bus upgrading measures is what the obstacles to such improvements are. The answers of transit experts, presented in Figure 3.6 together with the answers to the questions on the same subject given by transit operators (Figure 3.2), lead to some very interesting conclusions.

The diagram in Figure 3.6 shows that one obstacle, lack of funds, stands out as far more important than the others: 23 out of 24 respondents say that this obstacle exists always or often. This is somewhat surprising because most of the improvements are not highly capital-intensive. This problem may exist because of inadequate attention given to the project which leads to upgrading of bus transit systems. Inadequate funding may be blamed on all levels of government, from the federal and state to the local authorities and transportation/highway departments which in many states still consider that only auto travel is in their jurisdiction, while bus transit improvements are somebody else's problem.

Except for the insufficient funds as the obstacle, all other seven obstacles have been rated rather uniformly. Each one of them has been described as an often encountered obstacle by 12 to 16 out of 24 respondents. Again, there is not a single problem, but a set of rather deeply rooted obstacles.

Table 3.6 Summary of the comments (Question 7)

No.	Please give any additional comments or suggestions about bus transit system improvements which are relevant to our study.	Frequency of answers
1	The bus must be made more competitive with auto (travel time, speed, reliability)	2
2	Preparation of good planning, operational and maintenance program	2
3	Highway and other physical measures must be matched by a quality operation by providers of the service (good accessible vehicles, proper supervision)	1
4	Fare collection system should contribute to the easiness and convenience of usage	1
5	Service improvement from the user's perspective (stop location, park-and-ride facilities, good interchange with other modes)	1
6	Buses need permanence-identity	1
7	Poor design and information at bus facilities should be overcome	1
8	Better marketing	1
9	Most improvement decision are made by the city government and politicians	1
10	Physical and tariff integration among all transportation modes	1
11	Fare payment before boarding	1
12	Obtaining public/political consensus	1
13	Need for success stories about transit improvements	1

Survey of 24 transit experts

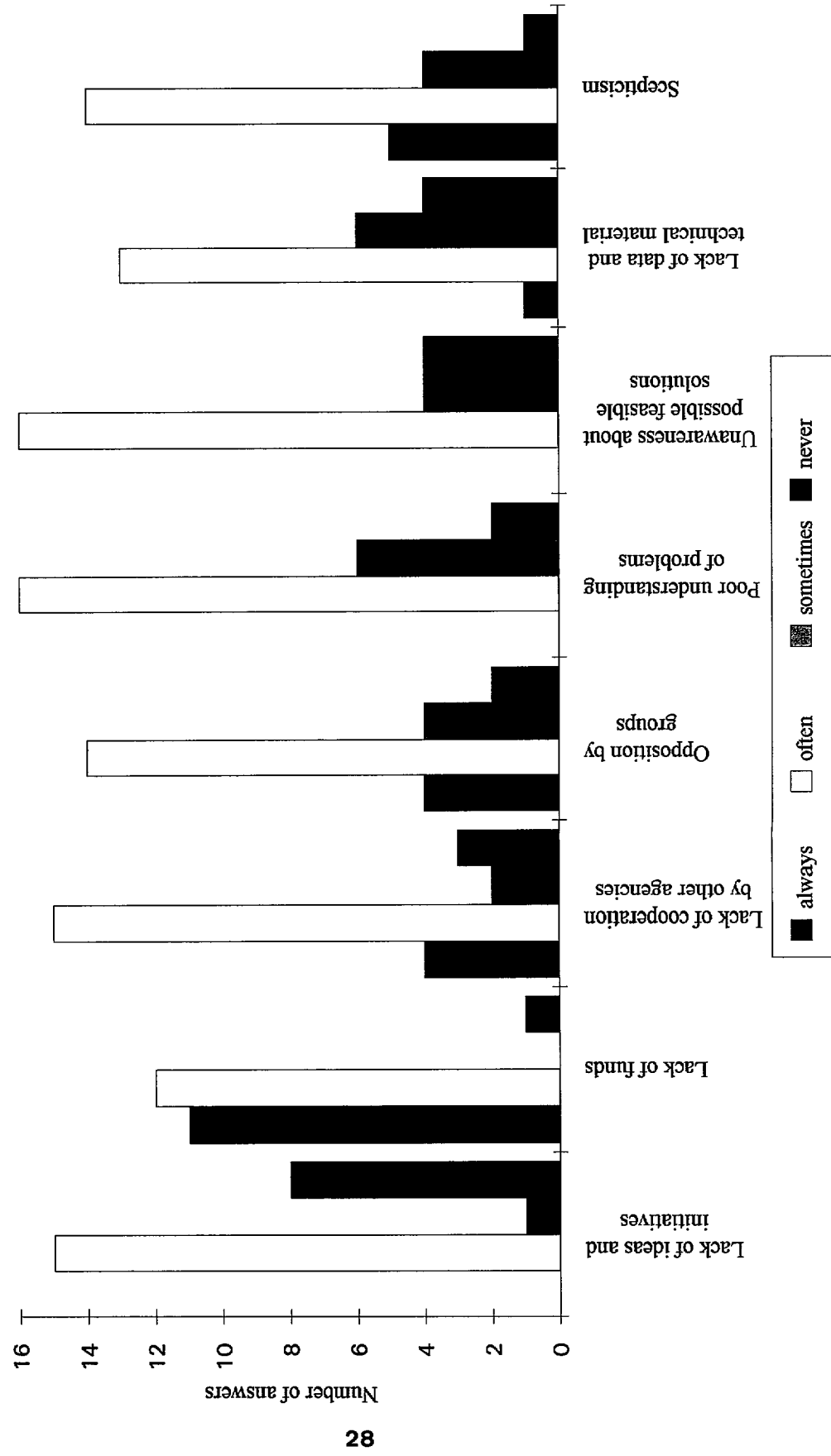


Figure 3.6 Obstacles and difficulties in introducing improvements to bus services (Question 3)

Grouping the obstacles, one can see that “lack of ideas and initiatives”, “poor understanding of the problem”, “unawareness of possible solutions” and “lack of data and technical material” generally indicate that there is lack of expertise: in many cities there are few competent engineers, managers, planners and other experts in the transit agency, as well as in governmental transportation departments (at the city and state levels). Put in a blunt statement, buses are operated in many cities in a very amateurish manner.

An equally or even more important obstacle to bus upgrading is the lack of cooperation by other agencies and other interest groups. It is very common that the city’s department for streets and the state transportation or highway departments directly oppose improvements of bus services: provision of special lanes, signal priorities, elimination of parking to improve the flow of buses, etc.

Even more than neglect, in many states these departments work actively on downgrading of bus services. As an example, the Pennsylvania Department of Transportation has pressured the Port Authority of Allegheny County (the Pittsburgh transit agency) to accept downgrading of its busways into HOV lanes. Similar pressures to downgrade HOV lanes from 4+ to 3+ and 2+ facilities have been exerted by the Connecticut Department of Transportation in Hartford, Texas Department of Transportation in Houston, Washington State Department of Transportation in Seattle, and others. In spite of the great efforts to broaden the domain, jurisdiction and mentality of the old-fashioned Highway Departments which have been made during the last 25 years, the results are less than outstanding. Many Highway Departments have changed their names into Departments of Transportation. Many state laws, as well as the latest federal law - the Inter-modal Surface Transportation Efficiency Act (ISTEA) of 1991 - explicitly require intermodalism and reduction of vehicle-miles traveled (VMTs). Yet, the narrow orientation toward one mode only still dominates many of the state and city “transportation”, actually highway departments. Obviously, more energetic education and enforcement of the ISTEA provisions are badly needed.

The two major obstacles discussed here, lack of expertise and opposition by other agencies, organizations and lobbies, have resulted over the years in the last obstacle shown in Figure 3.6: skepticism about any possibility for improvements, and a deeply rooted defeatist “it cannot be done” mentality in many governmental departments as well as in transit agencies.

Chapter 4

BUS SERVICE **PRIORITIES**: RATIONALE AND **OBSTACLES**

In this chapter the rationale for favoring public over private transportation is presented. Then, the methods for achieving a desirable balance between the two categories and the difficulties in implementing that balance are discussed.

One of the basic problems in urban transportation is how to achieve the balance between public and private modes of travel. In many ways preference of individuals, particularly their short-term decisions about mode selection, come out logically in favor of the private automobile. Looking at different modes together as system, however, and searching for a long-term improvement of mobility and efficiency of transportation, there is a strong rationale that in most cases, particularly in urban areas, transit should be favored over private transportation as much as possible.

Consequently, like in many other areas of human society, there is a dichotomy between the interests of the individual (micro scale of transportation) and the interests of the group, aggregation of system users, or, globally, the entire society. Similar dilemmas are found in regulating human behavior with respect to movements on streets (e.g., limitations of locations where pedestrians are allowed to cross streets, restriction of vehicle movements on certain streets to one direction only, parking regulation, etc.).

There are two general categories of measures which can be used to achieve the inter-modal balance between transit and auto: transit incentives and auto disincentives. The focus here is on transit incentives referring specifically to the bus mode. Auto disincentives, such as limiting parking capacity, increasing parking charges, introducing road pricing, discontinuing federal subsidies through tax exemptions for many types of automobile use, etc., are out of the scope of this report.

4.1 Reasons for Preferential Treatment of Buses

The rationale for providing priority treatments of buses over private cars and other vehicles include the following major points.

1. It is a standard practice to favor public over private facilities: the society pays from

its general funds for public schools, public parks and other public facilities; government does not support private schools, private golf courses, and other private facilities. In the case of transportation, transit is the only mode that provides mobility for all citizens and thus contributes to the basic living standard of the entire population.

2. Due to their large size, buses provide much higher transporting capacity than automobiles. They take less travel area per person-kilometer and require lower total cost for transportation than the private automobile. Therefore, buses have inherently much higher productivity and efficiency of transportation whenever there is a sizeable travel demand in a corridor.

3. Buses have far lower negative side effects, such as less pollution and energy consumption per person-km transported.

4. Bus priorities are needed to give transit faster and more reliable service and thus counteract the advantages an individual finds in using; the automobile, such as personal convenience and privacy, and extremely low out-of-pocket cost. These advantages are very attractive to the auto users, particularly because they are not charged for any social and environmental impacts which auto travel causes. Transit must offer a comparable set of advantages in order to attract any choice riders.

5. Bus priorities are justified also by the fact that transit in general is a key element which allows creation of more human-based city and more livable urban environment than in the cases where all travel is performed by the private automobile only.

While there are many ways of improving bus services, by far the most important one is physical separation of buses from other vehicles on streets and highways. This separation is important for many reasons.

First, it allows faster, more reliable, safe and comfortable travel for passengers.

Second, bus separation from general traffic is the only way of achieving speed comparable to that of the automobile, because higher running speed of buses free from congestion can compensate for additional time required for stopping at bus stops.

Third, separate rights-of-way, stations and other infrastructure give the bus service a distinctive image. These characteristics make bus service much more attractive to the passengers than individual buses mixed in general traffic can ever achieve. The advantages of a distinctive

physical system are not only limited to immediate attraction of passengers; they also give the system a character of permanence and, therefore, provide a potential to interact with the land use, and contribute to the shaping of land uses, urban form, and, finally, the quality of urban life.

4.2 “Flexibility” of Bus Services: Advantage or Liability?

The fact that buses can operate on most streets mixed with general traffic and require few extra fixed facilities is often considered to be their great advantage, particularly in comparison with rail transit. Buses require very low investment and their routes are flexible, meaning that their alignment can be changed without any great effort.

This “flexibility” of buses, however, is grossly misunderstood and misused. It is always presented as if it was a great advantages of the bus mode. Actually, while it is an advantage for low and moderate passenger volumes, this flexibility also implies lack of permanence, lack of distinction from other traffic, and great difficulty in achieving separation of buses from other vehicles. Whenever a separate bus lane is provided, that strip of asphalt is very attractive to all other vehicle drivers. In many cases in this country political pressures, even court decisions, have managed to prevent introduction or even discontinue existence of potentially excellent busway facilities. Many successful busways have thus been converted either to HOV roadways, or to general purpose facilities. Consequently, bus compatibility with other highway traffic is a major liability of this mode whenever distinctive high quality transit has to be provided.

The misuse of the concept of “flexibility” as a great advantage can be illustrated by many examples. “Flexible routing” means that service is individualized, such as taxi service; but it also means that people who have bus service may soon lose it because routing can be changed. “Flexible scheduling” may imply that users cannot rely on the convenience of a fixed schedule. “Flexible pricing”, often found in taxi services, is inherently more likely to lead to illegal overcharging of passengers than “fixed pricing” which users can easily understand.

Looking nationally, excellent bus facilities in many cities that were planned and built in the early 1970’s have by now been downgraded to indistinguishable part-time bus operations which help handle the high peak hour automobile volumes, but fail to provide all-day regular bus service which is an attractive alternative to automobile travel.

It is clear that a rational approach to urban transportation leads to a policy of giving

priorities to transit systems over private automobile. The priorities include a variety of physical and operational measures, but by far the most important measure is the separation of buses from other traffic. This rationale has, however, failed in most cities across the United States under the pressures of highway interest groups and failure to understand the long-term system aspect of intermodal distribution of urban travel.

4.3 Obstacles to Implementation of Preferential Treatments for Bus Services

A major obstacle to the implementation of this rationale is the full physical compatibility of buses with other traffic. The public, and even most of the transportation authorities and planners, are blinded by the attraction of the “free space” between buses on exclusive busways. They do not understand that “filling the space” with the automobiles and other vehicles deteriorates the performance of buses and, in the long run, destroys the concept of a Bus Transit System. It is paradoxical that to achieve an independent and competitive transit system, it is necessary to introduce transit technology which physically rather than functionally and legally prevents entry of other vehicles.

The relationship between the private and public transportation modes, i.e. provision of various types of transit priorities, is crucial for solving many urban transportation problems. Yet, this issue is poorly understood and its importance is seldom recognized in our cities. Most of the transportation policies, particularly those relating to buses, are therefore based on narrow and short-term aspects of operations, rather than on a comprehensive, long-term system basis. The most acute current problem of the relationships of transit to private vehicles, reflected in the issue of busways vs. HOV lanes, is analyzed in some depth in the next chapter.

Chapter 5

COMPARATIVE ANALYSIS OF BUSWAYS AND HOV LANES

When vehicular volume on a transportation facility (street or highway) exceeds the capacity of that facility, the result is a state of congestion, similar to overflowing rain sewers or rivers; it is an undesirable condition. However, while other facilities, such as electrical networks, pipelines or rail transit lines, continue to operate at capacity conditions with their maximum throughputs, congested highway traffic is highly inefficient: due to inadequate control of individual drivers' behavior on a highway, congested conditions results in a decreased throughput, as well as lower quality of service and greater negative impacts on the city and environment.

Expressed in very general terms, congestion on an existing street or highway leads to three groups of problems: first, reduced mobility due to longer travel time and lower reliability; second, increased cost due to time losses, inefficient vehicle operation, accidents, inconvenience, etc.; and third, the negative system impacts on society and environment greatly increase. Thus, the ultimate goals in upgrading a transportation facility are to increase mobility of passengers, decrease the cost of operation, and reduce the negative indirect impacts of transportation.

5.1 Objectives of Introducing Upgraded Rights-of-Way

A general conceptual flow of the means, objectives and goals in improving transportation in a given corridor, or in an entire urban area, is shown in Figure 5.1. It will be shown in subsequent text that the direct objective in many actions toward improving transportation is to achieve a shift of travel from the private automobile to transit. The figure shows that there are a number of means for achieving this objective. They consist of two groups: **auto disincentives** - measures which discourage use of the private automobile, such as introduction of realistic charges for auto travel, limitation of parking or retention of congested conditions; and, **transit improvements**, which include separation of rights-of-way and various priorities for transit vehicles, higher speed, reliability, comfort, as well as enhanced transit system image.

The figure also shows that the objective of changing modal split from auto to transit leads to two stages of final goals: first, increased capacity and productivity, which ultimately result in decreased cost and improved mobility; and, reduced number of vehicles travelling on the facility,

Means:

Auto disincentives:

- Limited parking
- Parking pricing
- Road pricing
- Limited street/
highway capacity

Transit improvements:

- Separate R/W
- Higher speed, reliability
- Fare incentives
- Distinct image

Objective:

Shift of travel from auto
to transit

Goals:

I

- Increased transport capacity
- Increased productivity

II

- Increased mobility
- Improved urban design
and environment
- Better quality of life

- Reduced number of vehicles
and VMT

- Decreased cost of transport
- Decreased negative
environmental impacts
- Reduced energy
consumption

Figure 5.1 Means, objectives and goals in improving transportation by shifting auto travel to transit

which leads to various kinds of environmental improvements, reduced energy consumption and enhanced quality of urban life.

5.2 Alternative Solutions for Congestion Relief

Since congestion results from traffic volume which exceeds facility capacity, there are two ways to relieve this condition:

1. **Decrease the number of person trips (travel demand).** Staggered work hours, telecommuting and similar activities which change working times and habits belong in this category. Discussion of these measures, which can alleviate the congestion problems but have many hidden negative consequences, are out of the scope of this study.
2. **Increase capacity of the facility.** For a given mode of transportation and system technology, this can be achieved in three different ways:
 - a. **Widen the facility** (increase the number of lanes). Experience of recent decades has shown that adding lanes to the existing streets and highways has diminishing returns and usually leads, in the long run, to the undesirable result of increased VMT's. The reason for this is that when there is additional lane capacity, people tend to switch to lower occupancy vehicles and drive longer distances. Eventually, most travelers drive as single occupants of vehicles, which is by far the least productive form of travel.
 - b. **Induce travelers to use higher capacity vehicles**, which may vary from higher occupancy private cars to paratransit, minibuses and transit buses. Travel in higher capacity vehicles results in decreased vehicular flow and thus in greater capacity and efficiency of traffic flow.
 - c. **Improve traffic flow through better operation and control.** This improvement includes measures which separate vehicles into different lanes by physical type (cars, buses, trucks), or by functional category (public, driven by professional drivers only, from private). Eventual use of the IVHS measures will also represent a means for improved traffic flow.

By far the most effective way of implementing the measures 2b and 2c is through a shift of travel from auto to transit, because that shift results in a drastic decrease in the number of

vehicles and, thus, increases the capacity of the roadway facility. The disincentives to auto and concurrent improvements to transit, which are needed to realize this intermodal shift of travel, are most effectively achieved through provision of priority lanes for transit. The independence of buses from general traffic gives them higher speed, reliability and stronger identity of service. Different methods for implementation of this priority, such as busways and HOV facilities, are analyzed next.

5.3 Classification of Vehicles and Right-of-Way Facilities

If vehicle types are plotted on a diagram of passenger vehicle occupancies vs. area occupied by one transported passenger, shown in Figure 5.2, it can be seen that buses are by far the most efficient vehicles with respect to the utilization of highway lanes. The bus mode has far greater passenger transporting capacity than other highway modes. The second group of vehicles are minibuses and vans, which overlap with the low range of bus occupancies. Finally, passenger automobiles take much greater area per passenger, so that they are the mode with the lowest transporting capacity and therefore least efficient in area consumption among all highway modes.

The great variety of highway facilities with preferential treatments can be defined by the classes of vehicles permitted to use them, as shown in Table 5.1. This table presents a systematic review of priorities or separations of different modes and vehicle classes. Six vehicle classes are grouped into four facility categories.

Category I facility serves public transport vehicles - transit buses - exclusively; examples of such facilities exist in Ottawa, Pittsburgh and Sao Paulo. That category, “**Busway**”, is comparable to an LRT system by its regime of operation, except that technologies of the two modes differ. The busways have by far the strongest identity and image of all categories of preferential highway facilities.

Category II facility is also open to all other buses (long-distance, charter and private coaches, etc.) and to vans, which are usually various types of paratransit and semipublic Vanpools (belonging to companies, universities, hospitals, etc.). Compared to category I, this “**Public and paratransit HOV facility**” accommodates more vehicles and carries more passengers than a comparable busway, but transit vehicles are exposed to more disturbances; they have more

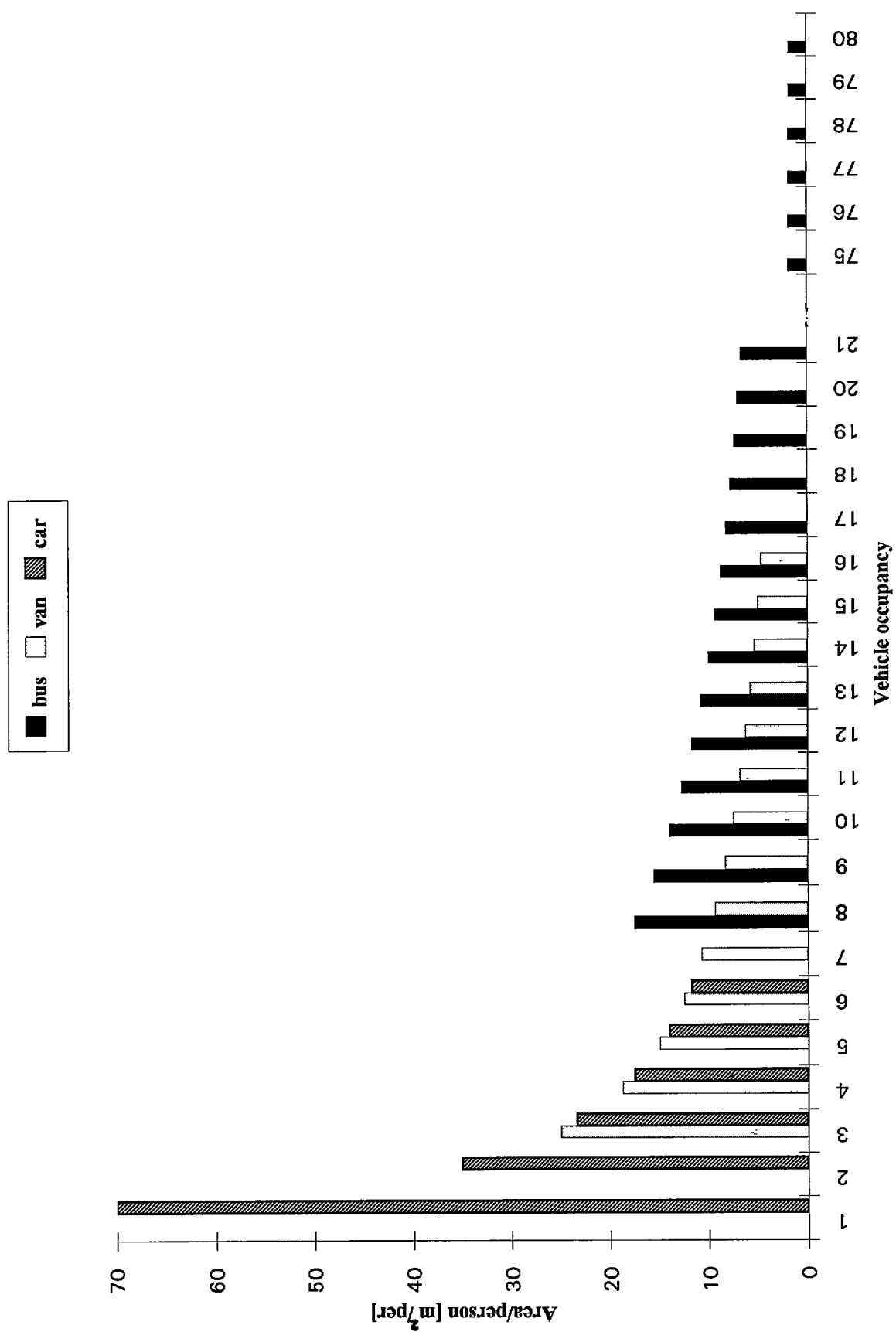



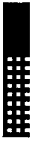




Figure 5.2 Area requirement per person for different classes of vehicles

Table 5.1. Classification of vehicle categories and right-of-way facilities

Facility category	Vehicle classes permitted		Type of facility	Functional categories of vehicles
I	1. Transit buses		Busway	Public transit
II	2. Any buses, taxis and vans		Public HOVs lanes/roadways	Public and paratransit HOV
III	3. 4 + pass. cars		HOVs 4 + lanes/roadways	Any HOV
	4. 3 + pass. cars		HOVs 3 + "	
	5. 2 + pass. cars		HOVs 2 + "	
IV	6. SOVs, trucks		General traffic facility	Basic uncontrolled highway

Note: The bars in each facility category represent the vehicle classes permitted. Lengths of the bars represent typical relative volumes of the respective vehicle class.

Preceding classes Added classes



Total traffic volume in the facility

competition and less distinct image.

Proceeding to **Category III**, there is a major change. Instead of only public and semi-public vehicles with professional drivers, “**HOV facility**” allows entry to a much greater number of vehicles, referred to as “carpools”. The definition of car-pools, as well as of HOV’s, has changed with time from the vehicles with at least four passengers (4+), which are mostly organized commuter carpools, to the cases where vehicles with 3 or more (3+), and finally, with 2 or more (2+) passengers are included. This development and its consequences deserve a careful analysis.

Category IV is an **unrestricted highway** carrying all vehicle classes.

5.4 Backsliding of Bus Transit Services due to Vehicle Mix

Allowing private automobiles into preferential lanes changes the character of such lanes considerably for two reasons. First, vehicular volume increases greatly. The promoters of lowering the minimum occupancies of vehicles permitted to use the HOV facility claim that thereby “the gaps between buses are utilized”. Although that is correct in the short run, this is a naive layman’s view. Actually, the price that this “utilization of gaps” carries is substantial: higher volume decreases speed, reliability and safety of traffic. Thus it affects negatively the flow of the truly high occupancy vehicles, buses and vans. The level of bus service is further decreased by the fact that the facility is used not only by professional drivers, but by any licensed drivers, so that the regulation and quality of driving are compromised. The vehicle composition is non-uniform, resulting in more friction. Moreover, control of vehicle classes for entry and use of preferential lanes is much more difficult; enforcement by police is often a major problem.

To systematically evaluate the effects of converting busways into HOV facilities, the differences which such a change brings are listed on the next page.

This listing clearly shows that all the benefits from the conversion from a busway to an HOV facility are accrued by passengers of other than transit vehicles. Transit passengers, existing and potential, only have losses from these changes.

Table 5.1 shows that as roadway facilities are changed from Category I to Category III, or from vehicle class 1 downward, eventually to vehicle class 5 (2+ passenger cars), more and more classes of vehicles benefit. In the short run the total number of passengers carried, as well

HOV facilities, compared with exclusive bus facilities, result in:

- + Reduced travel time for high-occupancy auto passengers;
- + Decreased congestion on parallel regular lanes or roadways: reduction of travel time for other auto users;
- + As a result of the preceding two changes, increased productive capacity of the entire facility;

Decreased performance (reduced speed, reliability, safety) of buses due to increased traffic volume and nonuniform traffic composition;

A loss of the distinct advantage of public transport (buses) in performance and in level-of-service which fully separated busways give it over private transport (autos);

As a consequence of the preceding two factors, some diversion of passengers occurs from bus stops back to autos, particularly to Vanpools and car-pools; moreover, these travelers often use illegally park-and-ride spaces provided for bus passengers;

Additional loss of passengers due to their “stealing” by auto drivers from bus stops to form “ad hoc carpools”: direct loss of bus revenue;

as the physical productivity of the roadway, increases, but the level of service decreases due to the much greater vehicular volume. Even more importantly, as non-transit users gain while transit users lose in service quality, the competitiveness of transit is decreased and, consequently, riders are lost, leading to a decrease of service frequency and downgrading and further passenger losses - the well-known downward spiral of transit use.

The priority of transit buses is further reduced by the fact that the other lanes of the same highway now have reduced traffic volumes, so that even the lower occupancy automobiles, including the single-occupant-vehicles (SOV's), have improved travel conditions. This gives SOV's an additional advantage over transit buses. The phenomenon of passenger cars “stealing” bus passengers at bus stops prior to entering HOV lanes contributes to further losses of bus patronage, resulting in reduced revenues and, eventually, decreased quality of transit services.

While all these problems occur as soon as any automobiles (i.e., 4+) are permitted into

the HOV facility, the situation becomes progressively worse with the transition from 4+ to 3+ and, ultimately, to the 2+ regime. This last type of facility is actually a regular highway with prohibition of only SOV's and trucks.

5.5 Downgrading from Regular to Commuter Transit

An additional change, also detrimental to transit, happens when a roadway is converted from Category I to II or III. Category I facilities - busways - usually operate as two-way roadways, providing bidirectional all-day service. They represent regular transit, or BTS, which is competitive with the automobile and serves all passengers traveling among many points throughout a network.

Bus transit on roadways of Categories II and III - HOV facilities - on the other hand, usually operates in one direction (reversible) during each peak period and offers no services at other times. Such commuter transit provides “many-to-one” type of services in radial directions, serving only peak-hour travel from suburbs into the CBD and vice versa. It does not serve off-peak, non-work trips, trips that are not radial, “reverse commuting” to suburbs, nor even trips among different points along the served corridor.

Thus, buses on HOV facilities provide a service much more limited in time, direction, area coverage, etc., than buses on exclusive busways. This difference between the two types of services has major implications on the potential and role of transit in urban transportation. While busways represent infrastructure giving transit system a distinct identity and image, which make it competitive with the automobile, buses on HOV facilities are just one of the types of vehicles, without any distinct image; they are literally an “attachment” to the highway system, on freeway alignments which often do not follow the optimal directions for transit services.

The image of buses as a high-quality prioritized transit is greatly diminished when busways are converted into HOV facilities. At the same time the main competition to buses, a significant number of private automobiles, is allowed to share the facility. The car-pools are given the same priority as transit buses, in spite of the fact that they are private vehicles and take several times greater highway area per passenger than buses, as Figure 5.2 shows.

How can such a deterioration of transit services be introduced in many cities of the United States, often under the claim that such a change represents a transit “improvement”? The

explanation lies in the fact that the arguments in favor of converting busways into HOV facilities, as well as HOV lanes into general traffic lanes, are advanced by the groups which represent auto users who directly benefit from such changes. The bus riders are affected very seriously, but indirectly, through gradual lowering of service quality and loss of passengers. More importantly, transit riders have a weaker political representation. This was clearly shown in the cases like Santa Monica Freeway, where a judge prohibited introduction of HOV lanes: the lobby of auto users prevailed over professionals promoting a long-term system improvement.

Consequently, from the perspective of the total social interest and long-term transportation system improvement, conversion of exclusive busways into HOV facilities never represents a gain for transit passengers. In most cases it benefits the HOV users other than bus riders, i.e., users of the modes which compete with buses. In some cases the change is directly counterproductive. In the long run, the loss of transit priority is detrimental not only to transit passengers, but to the entire balance of transportation modes. Finally, both CAA and ISTEA require, explicitly or implicitly, that capacities of highways serving SOV's and VMT's should not be increased; instead, the overall average vehicle occupancy and transit use should be increased. Conversions of busways into HOV facilities have results directly contrary to these requirements.

5.4 Numerical Model for Analysis of Different Highway Upgrading Measures

Following the wave of conversions of busways into various types of HOV facilities, presently the only large network of busways in North America exists in Ottawa. The Ottawa system represents by far the highest quality and most successful BTS on the continent. In the United States only Pittsburgh has managed to retain busways. Other cities, including Washington (Shirley), Los Angeles (El Monte), Houston, Seattle and many other cities have downgraded most of their facilities not only by converting them into HOV facilities, but also by operating them as peak-hour, usually unidirectional roadways.

To illustrate the discussion presented above in a quantitative manner, a "model freeway" in an urban corridor, sketched in Figure 5.3, is created. Alternative schemes of priority facilities are analyzed with respect to the different shifts in vehicle classes, levels of service and changes in modal split and average vehicle occupancies. The assumptions, four different alternative facilities, and the results of the analysis are presented here.

THE MODEL FREEWAY



Vehicle classes	Busway	HOV
Convert	Convert a lane to busway - C/B	Convert a lane to HOV facility - C/H
Add	Add a busway - A/B	Add HOV facility - A/H

Figure 5.3 Present and alternative cross-sections of the model freeway with priority lanes

The model and assumed initial conditions of the analysis in terms of lane geometry and demand are typical for an urban radial freeway with saturated peak-hour flows. They are presented below and summarized in Table 5.2.

Lane configuration of the existing freeway:	4 lanes per direction;
Total number of persons traveling:	12,000 prs/hr;
Number of vehicles:	1,000 cars/hr with 2 prs/car; 7,000 cars/hr with 1 prs/car; 60 buses/hr with 50 prs/bus;
Average occupancy of all vehicles:	1.49 prs/veh;
Average number of vehicles per lane:	2,015 veh/hr;
Current traffic flow Level of Service:	E;
Latent travel demand (trips which would be made if the freeway condition are improved):	3,000 prs/hr;
Composition of the latent demand:	1,000 car captives, 1,000 transit captives, and 1,000 choice travelers.

With respect to the provision of an upgraded facility, two approaches are considered: convert two present lanes (“Convert-a-lane”) and add (construct) two new lanes (“Add-a-lane”). Conversion of 1+1 existing lanes into an upgraded roadway (for certain vehicle classes only) would favor the selected classes of vehicles and suppress the classes remaining in the general lanes (the volume-to-capacity ratio in the general purpose lanes would be increased, so that level-of-service would be reduced). Construction of new lanes would, on the other hand, improve conditions for the selected classes, but it would also improve traffic conditions for the vehicle classes which would stay in the present 4+4 lanes due to the lower vehicular volumes.

By vehicle classes permitted in the upgraded facility, two categories are considered (see designations in Table 5.1): facility Category I - exclusive busway and Category III - HOV roadway (for simplicity, 2+ type is considered, but the cases for 3+ and 4+ are conceptually the same).

The two variations for the two cases make four permutations, as shown in Figure 5.3. C

Table 5.2 Initial conditions in the model corridor

Type of facility	Freeway with 4 general-purpose lanes per direction		
Vehicle classes and occupancies	Notation	Type of vehicles	Occupancy [prs/veh]
	A, A2 B ₅₀	1. Passenger car 2. Passenger car 3. Bus	1 2 50
Present and latent demand	Existing demand and number of vehicles by class		Latent demand
		[prs/h] [veh/h]	[prs/h]
	A,	7,000	7,000
	A2	2,000	1,000
	B ₅₀	<u>3,000</u>	<u>60</u>
	Total	12,000	8,060
Present average occupancy (prs/veh)	All vehicles combined		A, and A, only
	1.49		1.12
Traffic flow conditions	Saturated flow (2015 veh/lane/h), LOS E, mixed traffic, no trucks		

and A designate converted and added lanes, respectively. B and H designate busways and HOV facilities, respectively. Thus, the four cases are designated as C/B, C/H, A/B and A/H.

Each one of the four permutations is analyzed in the sequence shown as a flow chart in Figure 5.4. Column 1 is the present condition: a saturated facility with mixed traffic. The four cases are shown in column 2. Then, in column 3, the present volumes are reassigned to the facilities when the upgraded roadway is opened. Traffic conditions on each facility are evaluated, likely shifts of passengers among modes are estimated, and vehicular volumes are reassigned in column 4. Further, the new levels of service are evaluated and in the cases where the resulting level of service for an individual mode has been improved, the likely attraction of the latent demand was estimated and shown in column 5. The last set of boxes (column 6) in Figure 5.4 gives brief descriptions of the conditions and results for each one of the four cases.

The computations of traffic volumes, estimates of levels-of-service and of attraction of latent demand have been made for each one of the four cases and they are presented in Table 5.3. The wide columns with numerical values in this table represent the three assignments described in columns 3, 4 and 5 of Figure 5.4. The narrow columns in Table 5.3 give brief descriptions of the conditions and reasons for reassignments.

The results of these numerical model analyses, including the vehicular and passenger volumes and levels of service for the present (initial) situation and for the four alternative cases, are presented in Table 5.4. The four cases are designated in the same manner as in Figure 5.3: C/B, C/H, A/B and A/H.

The table shows that the C/B case is by far the best one with respect to achieving the goals of shifting the travel from automobiles to transit and reducing VMT's: this case has the smallest number of vehicles (6160) carrying 14,800 of the 15,000 present and potential travelers. The average vehicle occupancy of 2.40 persons/vehicle is much higher than in other three cases, and the modal split (last column) is 14% higher than in the A/B case and nearly 30% higher than in the cases with HOV facilities, C/H and A/H. Moreover, conversion of existing lanes is usually a much lower investment alternative than the option of adding new lanes.

The least effective case with respect to achieving the goals is A/H: it attracts 2500 of the 3000 latent travelers, but it actually results in a significant increase in the number of vehicles (from 8060 to 9580), aggravated congestion and virtually no improvement in modal split and

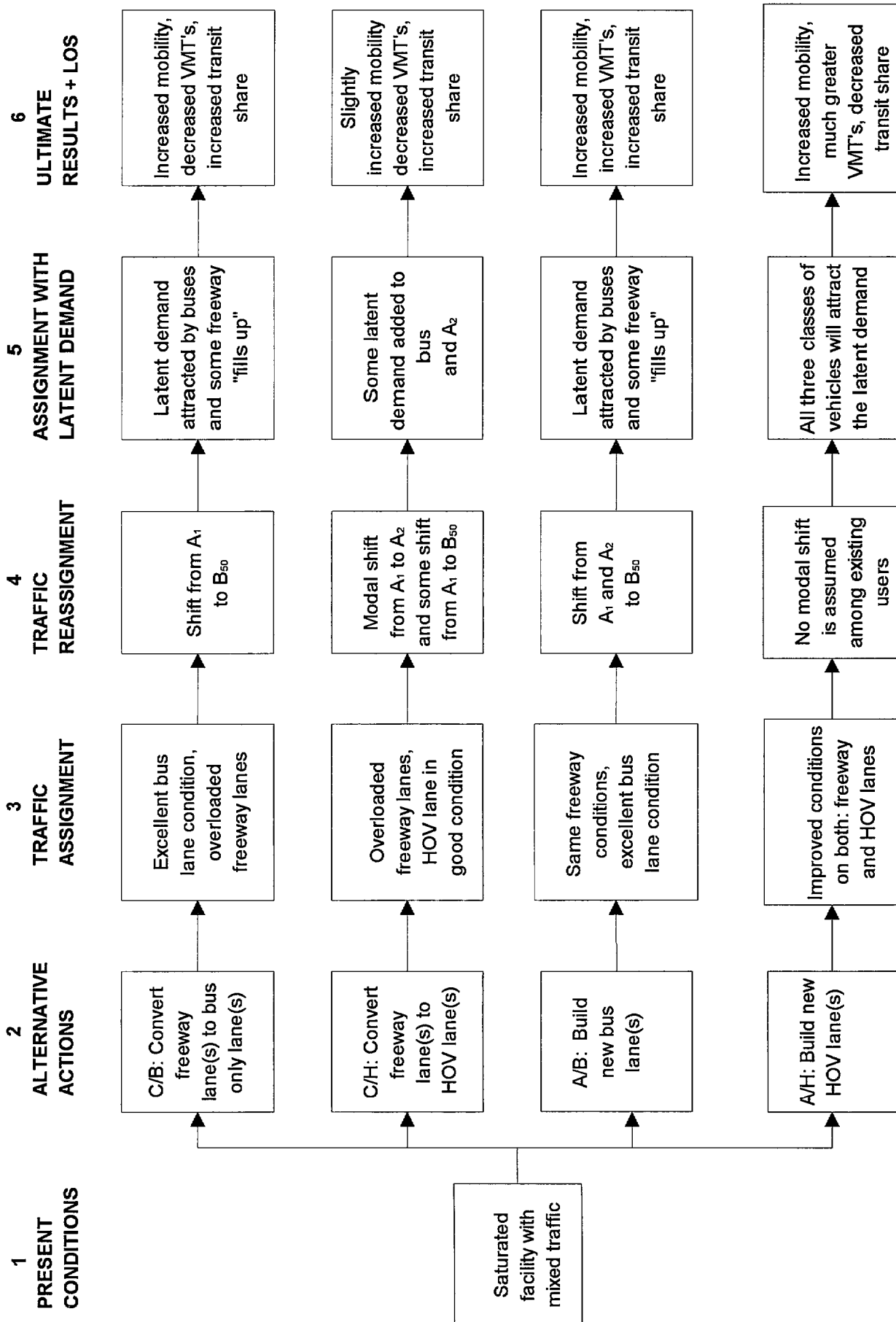


Figure 5.4 Flowchart of travel reassignments in the model facility

Table 5.3 Model of corridor travel and likely modal redistribution due to introduction of upgraded lanes

C/B. CONVERT A FREEWAY LANE TO A BUS LANE													
	Present volumes + immediate shift			Overloaded freeway lanes; modal shift A_1 to B_{50} and A_2 to B_{50}			Transitional state		The bus attracts latent demand of 2000 pass. (1000 bus captives + 1000 of those who have choice). Some latent demand is assigned to A_1 and A_2 (400 + 400).	Ultimate state			
Vehicle classes	A_1	A_2	B_{50}	Total	A_1	A_2	B_{50}	Total		A_1	A_2	B_{50}	Total
Persons/hour	7000	2000	3000	12000	4800	1200	6000	12000		5200	1600	8000	14800
Vehicles/hour	7000	1000	60	8060	4800	600	120	5520		5200	800	160	6160
Veh/hour/freeway lane Veh/hour/bus lane*	2000 \rightarrow 2667 0 \rightarrow 60 x 1.5 = 90				1800 120 x 1.5 = 180					2000 160 x 1.5 = 240			
LOS for freeway lane LOS for bus lane	E \rightarrow F E \rightarrow A				D A				E A				
Average vehicle occupancy	Total 1.49	A_1 and A_2 only 1.12			Total 2.17	A_1 and A_2 only 1.13		Total 2.40	A_1 and A_2 only 1.13				
% pass/h by transit	25.0%				50.0%				54.0%				
C/H. CONVERT A FREEWAY LANE TO HOV LANE													
	Present volumes + immediate shift			Overloaded freeway lanes; modal shift A_1 to A_2 and some A_1 to B_{50}			Transitional state		Ultimate state				
Vehicle classes	A_1	A_2	B_{50}	Total	A_1	A_2	B_{50}	Total	A_1	A_2	B_{50}	Total	
Persons/hour	7000	2000	3000	12000	6000	2600	3400	12000	6000	3100	3500	13000	
Vehicles/hour	7000	1000	60	8060	6000	1300	68	7368	6000	1550	78	7628	
Veh/hour/freeway lane Veh/hour/HOV lane*	2000 \rightarrow 2333 0 \rightarrow 1000 + 60 x 1.5 = 1090				2000 1300 + 68 x 1.5 = 1402				2000 1550 + 78 x 1.5 = 1667				
LOS for freeway lane LOS for HOV lane	E \rightarrow F E \rightarrow B				E C				E C/D				
Average vehicle occupancy	Total 1.49	A_1 and A_2 only 1.12			Total 1.63	A_1 and A_2 only 1.17		Total 1.70	A_1 and A_2 only 1.21				
% pass/h by transit	25.0%				28.3%				26.9%				

* Car equivalency factor of 1.5 is used for buses in order to determine the LOS (HCM Chapter 12-10)

Table 5.3 (cont'd) Model of corridor travel and likely redistribution due to introduction of upgraded lanes

A/B. ADD A BUS LANE														
	Present volumes + immediate shift			Due to the big difference in LOS some shift from A ₁ to B ₅₀ and A ₂ to B ₅₀ is expected.	Transitional state			The bus attracts latent demand (1000 bus captives + 1000 of those who have choice). Some latent demand is assigned to A ₁ and A ₂ (500 + 500).	Ultimate state					
Vehicle classes	A ₁	A ₂	B ₅₀		Total	A ₁	A ₂		B ₅₀	Total	A ₁	A ₂	B ₅₀	Total
Persons/hour	7000	2000	3000		12000	6500	1500		4000	12000	7000	2000	6000	15000
Vehicles/hour	7000	1000	60		8060	6500	750		80	7280	7000	1000	120	8120
Veh/hour/freeway lane Veh/hour/bus lane	2000 → 2000 0 → 60 x 1.5 = 90				1800 80 x 1.5 = 120				2000 120 x 1.5 = 180					
LOS for freeway lane LOS for bus lane	E → E E → A				D A				E A					
Average vehicle occupancy	Total 1.49	A ₁ and A ₂ only 1.12			Total 1.65	A ₁ and A ₂ only 1.10			Total 1.84	A ₁ and A ₂ only 1.12				
% pass/h by transit	25.0%				33.3%				40.0%					
A/H ADD A NEW HOV LANE														
	Present volumes + immediate shift			No modal shift is assumed among the existing riders.	Transitional state			All three classes will attract the latent demand (1000 + 1000 + 500).	Ultimate state					
Vehicle classes	A ₁	A ₂	B ₅₀		Total	A ₁	A ₂		B ₅₀	Total	A ₁	A ₂	B ₅₀	Total
Persons/hour	7000	2000	3000		12000	7000	2000		3000	12000	8000	3000	3500	14500
Vehicles/hour	7000	1000	60		8060	7000	1000		60	8060	8000	1500	70	9570
Veh/hour/freeway lane Veh/hour/HOV lane	2000 → 1750 0 → 1000 + 60 x 1.5 = 1090				1750 1000 + 60 x 1.5 = 1090				2000 1500 + 70 x 1.5 = 1605					
LOS for freeway lane LOS for HOV lane	E → C/D E → B				C/D B				E C/D					
Average vehicle occupancy	Total 1.49	A ₁ and A ₂ only 1.12			Total 1.49	A ₁ and A ₂ only 1.12			Total 1.51	A ₁ and A ₂ only 1.16				
% of pass/h by transit	25.0%				25.0%				24.1%					

Table 5.4 Summary of results of the numerical example

Case	No. of vehicles			LOS			No. of passengers/hour				Total aver. occu.	% of transit pass.
	A1 and A2	B ₅₀	Total	A1	A2	B ₅₀	A1	A2	B ₅₀	Total		
Present situation	8000	60	8060	E	E	E	7000	2000	3000	12,000	1.49	25.0%
C/B. Convert a freeway lane to bus only lane	6000	160	6160	E	E	A	5200	1600	8000	14,800	2.40	54.0%
C/H. Convert a freeway lane to HOV lane	7550	78	7628	E	C/D	C/D	6000	3100	3500	13,000	1.70	26.9%
A/B. Build new bus only lane	8000	120	8120	E	E	A	7000	2000	6000	15,000	1.84	40.0%
A/H. Build new HOV lane	9500	80	9580	E	C/D	C/D	8000	3000	3500	14,500	1.51	24.1%

average vehicle occupancy.

The two cases with busways, C/B and A/B, clearly result in situations where transit buses have a distinctly higher level of service than private automobiles. Thus, these two cases are far more successful in achieving the goal of shifting ridership from automobiles to transit.

The two cases with converting the lanes (C/B and C/H) do not attract as many latent travelers as the cases with adding the lanes, but they result in considerably lower vehicular volumes, thus decreasing VMT's.

Overall evaluation of the four cases, based on attraction of new transit riders, reduction of VMT's, and investment costs, indicates that the C/B case is clearly the most effective, while the A/H case is the worst. Actually, the A/H case is directly counterproductive, because it results in a decrease in the transit share of riders, in an increase of VMT's, and, in most cases, it involves a very high investment cost.

As stated in the beginning of this section, the model analyzed here is hypothetical, so that its numbers cannot be considered as exact and reliable. The assignments were made to indicate relative changes, rather than absolute values. The model has been used, however, to clarify the basic concepts of different cases in providing prioritized lanes and in selecting vehicle classes to be given priority. For that purpose, the results of the model are quite clear and convincing: its findings generally corroborate the real world conditions, as evidenced by the findings of the surveys.

5.7 Conclusions: HOV Facilities are often Detrimental to Transit

Comparing the two alternative provisions of preferential facilities, conversion of existing general purpose into preferential lanes is much more effective than addition of new lanes in shifting travel from automobiles to transit (and carpools). The reason for this is obvious: the preferential lanes have a much lower volume than the remaining general purpose lanes and therefore offer a distinctly higher level of service. When new lanes are added, the remaining general purpose lanes remain with lower traffic volumes. Their level of service is thus also increased, so that the advantage of preferential lanes is diminished. Moreover, the much lower cost of converting than constructing lanes also favors conversion over addition of lanes.

In the second decision, the choice between busways and HOV facilities, the former is distinctly superior to the latter in attracting transit riders and reducing VMT's. The reason is that busways give a greater advantage to buses over their competitors in terms of speed, reliability, etc.

Consequently, the C/B case is the most effective one with respect to the goals of increasing transit ridership, decreasing VMT's and cost-effectiveness of the investment in facilities; the A/H case is the worst, being often counterproductive with respect to the achievement of these goals. The fact that the trend in most cities has been to change from the best to the worst case for transit is highly upsetting.

Opening up HOV facilities from public HOV's to 4+, then to 3+ and, ultimately, to 2+ operations, has progressively diminished the function of such facilities as devices to encourage transit use. This trend is the most damaging case of backsliding of bus priorities, and it has become the major obstacle to creation of **Bus Transit Systems** in U.S. cities. The Federal Transit Administration, presently endorsing this trend, should reverse its stand and **adopt a clear policy of maximum upgrading of buses operated in exclusive busways as regular, all-day bus service, rather than as commuter services supplementing automobile travel on automobile-oriented freeway networks.**

Thus, the choice for all cities that want to create high-quality transit systems which can maintain reasonable balance with auto travel, has now been effectively reduced to rail and AGT systems only. Rail and other guideway technology systems physically prevent use of their rights-of-way by other vehicles and therefore eliminate pressures to "fill the empty spaces between transit vehicles".

STUDY FINDINGS AND RECOMMENDED POLICIES FOR CREATION OF BUS TRANSIT SYSTEMS

The basic objective of this study was to evaluate the present conditions of bus transit services in the U.S. cities and to analyze the reasons for the failures to maintain bus priorities. Recent considerable backsliding in bus preferential treatments has been given particular attention.

The surveys performed for this study clearly show that the present condition of bus services is far from satisfactory. The study presents an analysis of the prevailing conditions and problems, and recommends specific measures to upgrade bus services in North American cities, and thereby to contribute to the revitalization of our cities.

Findings and recommendations of this study are summarized here in five separate sections.

6.1 Role and Conditions of Bus Services

1. Bus transit is the most widely used mode of urban public transportation. It is operated in all cities which have transit services. Its significance for mobility of urban population, for economic efficiency of the city, and for quality of urban environment, is often underestimated.

2. Buses operating on streets in mixed traffic tend to attract only captive riders. Only **Bus Transit Systems (BTS)**, which have considerable physical independence from other traffic, can attract a significant number of choice riders.

3. Among the numerous improvements needed to create a **BTS**, physical separation of its facilities represents by far the most important measure. Separate facilities include busways, bus lanes on streets, HOV facilities with different sets of vehicle classes allowed, and various types of bus and inter-modal terminals.

4. Other upgrading measures include improved vehicle design, such as improved suspension, low floor, and lower emissions production; operating practices include field supervision, automatic vehicle monitoring (AVM) systems, passenger amenities, information and marketing.

6.2 Bus Service Improvements and Recent Trends of Backsliding

5. Realization of the importance of bus services during the 1970's led to the introduction of numerous measures for upgrading bus services, particularly construction of bus lanes and busways. However, surveys undertaken for this study show that in recent years there has been considerable backsliding, i.e., relaxation or elimination of bus preferential treatments, in many U.S. cities. Examples of such backsliding are abandonment of preferential signals and exclusive bus lanes through inadequate maintenance or lack of enforcement.

6. Major degrading of bus services has occurred through conversion of busways into HOV facilities and opening of these to increasing numbers of vehicle categories, often as far as vehicles with two persons deceptively designated as "high occupancy vehicles".

7. An analysis in this study shows that the conversion from busways to HOV facilities brings no benefits to bus passengers; it degrades bus services to commuter transit and encourages the main competition to buses, vanpools and car-pools.

8. Conversion of nearly all busways to HOV facilities in the U.S. has practically eliminated buses as an option for high performance, distinctive semirapid transit.

9. The U.S. is the only country which has systematically degraded busways into HOV facilities. Other countries which have constructed bus transit systems, such as Canada, Brazil, Peru and France, have retained these facilities for exclusive use of transit buses.

6.3 Present Conditions and Problems

10. The surveys conducted in this study have shown that **among all North American cities only Ottawa has an extensive high quality Bus Transit System.** That city stands far ahead of other cities in its policies favoring transit, coordination of land use development with bus transit stations, uncompromising exclusivity in **bus transit only** facilities, and a number of other supporting measures. Ottawa is also unique in the great success which bus transit has in contributing to the vitality of the city and avoidance of traffic congestion.

11. In the United States only Pittsburgh has major exclusive busways. Its two busways have a total length of 17.3 km. Only six of the other surveyed cities have any exclusive bus facilities on the streets, and most of these are very limited in length.

12. HOV facilities on freeways which are used by buses to various degrees have

considerably greater length than bus preferential facilities on urban streets. However, these two types of facilities have very different characteristics. Bus lanes on streets have many stops and they are used by regular transit buses throughout the day; HOV facilities on freeways are long roadways with few or no stops along the way used by transit buses which bring commuters from distant suburbs into the CBD. **Buses on HOV facilities thus do not represent regular transit services, but much more limited commuter transit.**

13. The present euphoria of HOV facilities development in the United States requires a careful scrutiny and revision. The basic concept of HOV priorities is an efficient means of encouraging use of higher productivity vehicles. This goal is achieved particularly effectively when existing highway lanes are converted to HOV lanes. However, construction of additional lanes on existing freeways which all vehicles with two or more occupants are allowed to use represents a “Trojan Horse” for highway capacity expansion which in nearly all cases results in substantial increases in VMT’s and increased air pollution. This development is in direct conflict with the explicit goals of the CAAA and ISTEA. This construction of new lanes, particularly when they are presented as 4+ HOV facilities and later degraded to 2+ facilities without an EIS analysis, represents a further circumventing of legal requirements. Use of transit funds for these facilities should be discontinued because it is directly counterproductive.

14. The results of the surveys show that special infrastructure for preferential treatment of buses in U.S. cities is extremely limited. This condition results in the fact that most buses in our cities serve mostly captive riders; bus services are not capable of competing successfully with the automobile as long as they utilize the same streets and highways.

15. This condition creates the problem that increasing traffic congestion leaves urban travellers without any alternative to congested highways. The growing congestion due to increasing VMT’s thus inevitably results in reduced mobility in urban areas.

6.4 Reasons for Backsliding

16. The surveys of transit agencies and transit experts, as well as review of extensive literature on bus transit, lead to the conclusion that the major reasons for failure to maintain bus preferential treatments are the following:

- a. Lack of clear policy favoring transit over other modes;

- b. Inadequate support and sometimes even opposition by city and, particularly, state transportation/highway departments;
- c. Federal policy (supported even by the FTA) endorsing HOV facilities, even where they replace busways and bus lanes, thus degrading transit services;
- d. Pressures by auto/highway interest lobbies;
- e. The false belief that “gaps between buses on highways can be utilized by other vehicles” without realizing the negative impacts such mixed traffic has on transit services and image;
- f. Regulation enforcement problems;
- g. Inadequate expertise and lack of initiative by transit agencies and traffic engineers.

17. In addition to the inadequate quality of bus services, this trend of backsliding of bus priorities creates an atmosphere of helplessness and lack of initiative among bus operators and urban transportation authorities. The performed surveys, experiences with professional society activities, and literature review all indicate a low level of activities on systematic improvements of bus services which are needed in order to realize the unused potential of this transit mode.

6.5 Recommended Policies and Actions

18. The present short-term palliative measures for “congestion relief”, which allow maximum number of vehicles, including SOV’s, to utilize every facility without a clear perspective of an efficient multimodal transportation system, should be replaced by a long-range coordinated multimodal transportation policy.

19. Transportation policies at all levels, from federal to local, should be revised to clearly endorse preferential treatment of all transit modes. The rationale for such a policy is based on many facts, such as:

Transit provides a public service;

Transit is more efficient in using space and resources, including energy, than all other highway modes;

Transit has lower negative impacts on urban environment than private vehicles;

Provision of mobility for all population makes transit essential for a viable economy, social equity and high quality of urban living.

20. Physical compatibility of buses with other highway vehicles should not represent an obstacle to their physical separation from other traffic. Exclusive bus facilities and maximum separation of buses through regulatory measures are a sine qua non for creation of high quality **Bus Transit Systems** which can successfully compete with the automobile, and thus play a major role in a multi-modal urban transportation system.

21. The policies regarding construction of new HOV facilities, their financing and definition of HOV's should be carefully revised to prevent their use for covert increasing of capacities for SOV's and ensure the compliance with the requirements regarding EIS, decrease of VMT's and air pollution production.

22. Transportation professionals should promote this recognition of bus transit as an important component of urban transportation in most cities.

23. Instead of treating buses as just one type of highway vehicles, government agencies and transportation professionals should work on educating the public about the important role **Bus Transit Systems** can play in revitalizing cities.



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APPENDIX 1 Questionnaire sample - transit agencies

QUESTIONNAIRE FOR THE SURVEY OF METHODS FOR UPGRADING OF BUS TRANSIT SERVICES

Please give the requested information for any bus improvement facilities or measures introduced in the last 10-15 years. Summarize information for all facilities. If this is not possible, give information about a particular facility with appropriate explanations. Where boxes are given, please check applicable item, such as:

Buses only ☐ HOV ☐

• Bus preferential lanes/streets/roadways refer to facilities with usage restricted to buses and certain other categories of vehicles. Bus lanes/streets or busways restrict use to buses only. HOV facilities allow use by buses and any other vehicles (taxis, vanpools and carpools) which carry at least a given number of persons. Some of these facilities are also known as diamond lanes/roadways.

1. Right-of-way Improvements Introduced in the Last 10-15 Years

1.1 Preferential bus/HOV lanes on streets

- ▶ Total number of streets with bus lanes _____
- ▶ Total length (one-way) of preferential lanes _____ miles
- ▶ Number of lanes/streets presently operating as initially designed _____
- ▶ Number of lanes/streets later modified
(redesigned, changed from exclusive bus to HOV, etc.) _____
- ▶ Number of bus/HOV lanes which have been discontinued _____
- ▶ length of discontinued lanes _____ miles

➤ Present usage of preferential lanes/streets:

Buses only ☐ Bus + taxi ☐ HOV ☐

If HOV, minimum vehicle occupancy (circle the number): 4 3 2

➤ Placement of lanes:

Curb (right-hand) lanes ☐ Median (center) lanes ☐

➤ Direction of bus travel:

With flow ☐ Contraflow ☐ Reversible ☐

1.2 Exclusive (physically separated) bus/HOV streets, roadways and malls

- ▶ Number of facilities: _____
- Of these, number of transit malls _____
- Number of exclusive busway/HOV roadways _____

- ▶ Total one-way length of these facilities: _____miles
- ▶ Number of facilities presently operating as initially designed _____
- ▶ Number of facilities which were redesigned or reorganized (e.g., changed from bus to HOV, or v. v.) _____
- ▶ Number of discontinued facilities _____
- ▶ Length of discontinued facilities _____miles

» Present usage:

Buses only Bus + taxi HOV

If HOV, minimum vehicle occupancy (circle the number): 4 3 2

» Direction of bus travel:

One-way Two-way Reversible

1.3 Bus preferential lanes on freeways

- ▶ Total number of freeway sections with bus or HOV lanes _____
- ▶ Total length (one-way) of bus/HOV lanes _____miles
- ▶ Number of facilities presently operating as initially designed _____
- ▶ Number of facilities later modified (redesigned, changed from exclusive bus to HOV, etc.) _____
- ▶ Number of bus/HOV lanes which were later discontinued _____
- ▶ Length of discontinued facilities _____miles

» Present usage:

Buses only Bus + taxi HOV

If HOV, minimum vehicle occupancy (circle the number): 4 3 2

» Placement of lanes:

Right-hand lanes Median (center) lanes

» Direction of bus travel

With flow Contraflow Reversible

1.4 Evaluation of Right-of-Way Improvements

▶ Answer the following evaluation of the above listed right-of-way improvements by checking appropriate boxes;

» Results of improvements:

	None	Minor	Major
1. - Increased ridership	<input type="text"/>	<input type="text"/>	<input type="text"/>

		None	Minor	Major
2.	- Increased revenue	<input type="text"/>	<input type="text"/>	<input type="text"/>
3.	- Decreased operating cost	<input type="text"/>	<input type="text"/>	<input type="text"/>
4.	- Increased service reliability	<input type="text"/>	<input type="text"/>	<input type="text"/>
5.	- Increased operating speed	<input type="text"/>	<input type="text"/>	<input type="text"/>
6.	- Increased safety	<input type="text"/>	<input type="text"/>	<input type="text"/>
7.	- Enhanced image of bus service	<input type="text"/>	<input type="text"/>	<input type="text"/>
8.	- Other	<input type="text"/>	<input type="text"/>	<input type="text"/>

» **Negative results and problems:**

1.	- Enforcement difficulties	<input type="text"/>	<input type="text"/>	<input type="text"/>
2.	- Lack of public understanding and support	<input type="text"/>	<input type="text"/>	<input type="text"/>
3.	- Resistance by affected groups (store owners, companies, residents)	<input type="text"/>	<input type="text"/>	<input type="text"/>
4.	- Interagency cooperation difficulties	<input type="text"/>	<input type="text"/>	<input type="text"/>
5.	- Increased operating cost	<input type="text"/>	<input type="text"/>	<input type="text"/>
6.	- Other	<input type="text"/>	<input type="text"/>	<input type="text"/>

» Are these facilities presently well accepted by passengers, by different agencies and groups and by the public in general? Do they add to transit image?

2. Stops and Stations Improvements

» **Spacings and locations of bus stops:**

	Yes	No
► Organized effort made to increase speed by longer stop spacings	<input type="text"/>	<input type="text"/>
► Improved shelters and amenities	<input type="text"/>	<input type="text"/>
► Improved information	<input type="text"/>	<input type="text"/>

» **Off-street stops/stations:**

- Describe any improvements to off-street bus stops and terminals

➤ Results of improvements:

- ▶ Have these stop/station improvements resulted in ridership increase, improved image, etc.?

➤ Negative results and problems:

- ▶ Have any of these improvement (such as increased stop spacings) met opposition by same groups?

3. Priorities at Intersections

➤ Number of intersections with bus priorities:

➤ Signal actuation:

special bus phases

☐

extended phases for buses

☐

➤ Layout:

- ▶ Modification of intersections for buses

bus bays

☐

turning roadways

☐

4. Improvements in Operations Control

- | | Yes | No |
|---|--------------------------|--------------------------|
| ▶ Is field supervision of service adequate? | <input type="checkbox"/> | <input type="checkbox"/> |
| ▶ Is radio-communication system adequate? | <input type="checkbox"/> | <input type="checkbox"/> |
| ▶ Is an automatic vehicle monitoring system used? | <input type="checkbox"/> | <input type="checkbox"/> |
| ▶ Additional comments | _____ | |

5. Improved Enforcement by Police and Transit Officers

- ▶ Does the city police provide assistance in speeding up bus services?

None

☐

Some

☐

Adequate

☐

- ▶ Are there higher penalties for impeding transit vehicles than regular traffic tickets?

Yes

☐

(How much?) _____

No

☐

► Can transit officers issue fines for parking violations?

Yes

☐

No

☐

6. Integration of Bus Lines

» Are bus lines/services integrated by these measures:

Type of facilities Modes	Joint terminal		Coordinated schedule or Timed transfer system		Joint fares or Transfers	
	Yes	No	Yes	No	Yes	No
Among bus lines	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Between buses and rail transit	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Buses and intercity (air, rail, bus)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. Public Information and Marketing

7.1 Do you have a well-organized information and marketing program for transit services?

7.2 Do you make special efforts to ensure "user friendliness" of services?

8. Transit System Development Policy and Strategy

8.1 Does your city have a policy of favoring and promoting transit use over other modes?

Yes

☐

No

☐

Comments _____

8.2 Is that policy implemented effectively?

Yes ☐ Somewhat ☐ No ☐

Comments _____

8.3 Is there a good cooperation among transportation authorities (departments of city planning, streets, traffic engineering and police, transit agency, parking authority, state DOT) in planning and implementing transit improvements (so-called Transit First Policy)?

9. Suggested Improvements

Thank you very much for your cooperation.

If you have any questions, please call Prof. Vuchic (215/898-8345) or Prof. Kikuchi (302/831-2657).

The person whom we can call if there are follow-up questions or clarification.

Name: _____

Tel.: _____ / _____

APPENDIX 2 List of Transit Agencies which Participated in the Survey

No.	City, Transit Agency	Address	ContactPersons
1.	Calgary, Canada CALTRAN	Box 2100, Station 'M' , Calgary, Alberta, Canada, T2P 2M5	Mrs. Ann McAlister, Transit Planner tel. (403) 277-9749
2.	Chicago, CTA	Merchandise Mart Plaza P.O. Box 3555, Chicago, IL 60654	Mr. David L. Philips, Director, Bus Service Communication, tel. (3 12) 664-7200
3.	Denver, RTD	1600 Blake Street, Denver, CO 80202	Mr. David Baskett, Director of Planning and Development tel. (303) 299-2333
4.	Hartford, CTT	100 Leibert Road P.O. Box 66 Hartford, CT 06141-0066	Mr. Stephen Warren tel (203) 522-8101
5.	Houston, METRO	P.O. Box 61429 1201 Louisiana Street Houston, TX 77208-1429	Mr. Gordon Zwillenberg tel. (713) 739-4819
6.	Los Angeles, RTD	425 South Main Street Los Angeles, CA 90013	Mr. Gerald Squier tel. (213) 972-4835
7.	Newark, NJT	1 Penn Plaza East Newark, NJ 07 105-2246	Mr. John Wilkins tel. (201) 491-7797
8.	Oslo, Norway	Post Box 2857, Toyen, 0608, Oslo, Norway	Mr. Jon-Oivind Storaker and Mr. Thor Haatveit tel. 02/7100 90
9.	Ottawa, Canada, OC Transpo	1500 Saint Laurent Boulevard Ottawa, Ontario, Canada, K1G 0Z8	Mr. Cohn Leech and Mr. Joel Koffman tel. (613) 714-6440 ext.354
10.	Pittsburgh, PAT	2235 Beaver Avenue Pittsburgh, PA 15233	Mr. Pete Donner tel. (412) 237-7240
11.	San Antonio, VIA	800 West Myrtle Street P.O. Box 12489, San Antonio, TX 78212	Mr. Cris Young tel. (5 12) 227-537 1
12.	San Francisco, MUNI	949 Presidio Avenue San Francisco, CA 94114	Mr. Peter Straus and Mr. James Lowe tel. (415) 923-6100
13.	Seattle, METRO	821 Second Avenue, Exchange Building Seattle, WA 98104	Mr. Mike Bergman, Senior Transit Planner tel. (206) 684-1593
14.	Washington, WMATA	600 Fifth Street, N.W. Washington, DC 20001	Mr. David Gunn, General Manager tel. (202) 962-1234

APPENDIX 3 Questionnaire sample - transit experts

QUESTIONNAIRE ON UPGRADING BUS TRANSIT SYSTEMS For Transit Experts

1. Please mark () the importance of the following criteria in evaluating measures for bus service improvements?

None Minor Major

- Increased operating speed
- Increased reliability
- Improved image of service
- Decreased operating costs
- Increased ridership (and revenue)
- Improved safety
- Other (specify) _____

2. Please evaluate effectiveness of different types of bus service improvements (low - L, Medium - M or High - H)

L M H

- Right-of-way separation:
 - Lanes for high-occupancy vehicles (HOV)
 - Exclusive bus lanes or streets
 - HOV lanes on freeways
 - Exclusive bus roadways
- Modernization of stops and stations
- Bus priorities at intersections
- Operations control (supervisors, radio communication, AVM) _____
- Enforcement of traffic regulations (by police & transit officers)
- Intramodal and intermodal integration of bus networks
- Public information and marketing
- Transit system development policy

3. What are the obstacles and difficulties in introducing improvements to bus services?

Never Often Always

- Lack of ideas and initiatives
- Lack of funds
- Lack of cooperation by other agencies
- Opposition by special interest groups (NIMBY)
- Poor understanding of problems
- Unawareness about possible feasible solutions
- Lack of convenient documentation and supporting technical material for innovations
- Skepticism & conservatism ("It cannot be done" attitude) _____
- Other _____

4. What are the reasons that bus service improvement sometimes deteriorate in time?

5. In your opinion, which are the most important changes which would facilitate implementation of bus service improvements and ensure their permanence? Include here such items as improved city government policies and actions, increased financing, more effective enforcement of regulations, acceptance of innovations by transit agency, better public education to understand problems and issues, etc.

6. Briefly mention cities and projects which are good examples of:

a. Successful upgrading of bus systems_____

b. Attempted bus improvements which were later discontinued_____

7. Please give any additional comments or suggestions about bus transit system improvements which are relevant to our study.

Thank you for your time, effort and expert opinion!

APPENDIX 4 List of Transit Experts who Participated in the Survey

1. Mr. Rogerio Belda, Executive Director Associacao Nacional de Transportes Publicos - ANTP Rua Augusta 1626 CEP 01304, Sao Paulo, Brazil	13. Mr. Herbert S. Levinson 40 Hemlock Road New Haven, CT 065 15
2. Prof. Heinrich Brandli Institut für Verkehrsplanung, Transporttechnik, Strassen- und Eisenbahnbau - IVT ETH Hoenggerberg, CH-8093 Zurich Switzerland	14. Sr. Angel Molinero USTRAN Av. Revolucion 2042-2 01090 Mexico D.F., Mexico
3. Mr. Dennis L. Christiansen Division head, System Planning Division Texas Transportation Institute The Texas A & M University System College Station, Texas 77843	15. Dr. Shigeru Morichi Civil Engineering Department Tokyo Institute of Technology 2-12-1 Ookayama, Meguro-ku Tokyo, Japan
4. Mr. Bruce B. Emory Manuel Padron & Associates Suite 414, 1175 Peachtree Street, NE Atlanta, GA 30361	16. Mr. Subash Mundle Mundle & Associates, Inc. 1520 Locust Street, Suite 801 Philadelphia, PA 19102
5. Mr. Chuck Fuhs Senior Associate, PBQ & D 505 S Main Street, Suite 900 Omaha, CA 92668	17. Mr. Tom Parkinson, P.E. President, TPTC Ltd. 111 - 1141 West Seventh Avenue Vancouver, BC, Canada V6H 1B5
6. Mr. Wolfgang S. Homburger Institute of Transportation Studies 109 McLaughlin Hall University of California Berkeley, CA 94720	18. Mr. Robert L. Peskin, Manager Peat Marwick Main & Co. 8150 Leesburg Pike, Suite 800 Vienna, VA 22180
7. Mr. David F. Howard, Director General Tyne and Wear PTE Cuthbert House, All Saints Newcastle upon Tyne NE1 2DA Great Britain	19. Ing. Luis Dominguez Pommerencke Coordinador de Infraestructura del Instituto Mexicano del Transporte Apartado Postal 1098 76000 Queretaro, Oro., Mexico
8. Mr. Jean-Christof Hugonnard Regie Autonome des Transport Parisiens 53 ter quai des Grands Augustins 75006 Paris, France	20. Mr. Tom Potter Taugbol og Overland Conrad Mohrsveg 9 5032 Minde, Norway
9. Herr Dipl.-Ing. Herbert Hussmann Hamburger Hochbahn AG Steinstrasse 20 2000 Hamburg 1, Germany	21. Herr Dipl.-Ing. Rust Hamburger Verkehrsverbund Altstadter Strasse 6 D - 2000 Hamburg 1, Germany
10. Mr. Robert A. Keith, P.E. NJT - Rail Operations 1160 Raymond Boulevard, Newark, NJ 07102	22. Dr. P. N. Seneviratne Civil and Environmental Department Utah State University Logan, Utah 84322-41 10
11. Mr. Thomas F. Larwin, General Manager Metropolitan Transit Development Board 1255 Imperial Avenue, Suite 1000 San Diego, CA 92101-7490	23. Prof. Nigel H. M. Wilson Department of Civil Engineering MIT, Cambridge, MA 02139
12. Herr Dipl.-Ing. Hans Leopold Hamburger Verkehrsverbund Altstadter Strasse 6 2000 Hamburg 1, Germany	24. Mr. Jeffrey M. Zupan 13 Jean Lane Chestnut Ridge, NY 10952

APPENDIX 5 Highlights of Individual Transit Agencies' Responses

In this appendix brief excerpts from transit agencies' questionnaires are given. They are organized as Basic Information, containing reported facts; Distinct Features, with any interesting specific facts or characteristics, as given by the agencies; and Comments, which contain relevant remarks obtained either from the agencies or from other sources of information.

1. Calgary - Calgary Transit

Comment:

Calgary Transit Agency has sent impressive material, but unfortunately it gives information only about the Calgary LRT System. It seems that the questionnaire answers are also related to the LRT. From the questionnaire it can be said only that:

- There is good planning and good treatment of transit in Calgary.
- The bus system is well integrated with the LRT.
- There is a major transit (LRT and bus) mall in the CBD, and one bus lane.

2. Chicago - CTA

Basic Information:

There are six bus lanes on streets (5.4 km), a transit mall (1.7 km) and about 200 intersections with some kind of bus priority treatments (special green phases or extended green phases).

Distinct Features:

- They did not experience any improvement due to the introduced bus priority treatments.
- The bus mall was successful, but it has been redesigned for mixed use under the pressure of the business leaders (a case of backsliding).

Comment:

A contraflow lane in the Loop was discontinued after a pedestrian (who happened to be an attorney), was hit by a bus.

3. Denver - RTD

Basic Information:

Two bus lanes on streets (total length 9.6 km); one transit mall (3.2 km) with specially designed low-floor buses for shuttle service - a very successful concept; and, one bus-only lane on a freeway (6.4 km).

Distinct Features:

- The existing preferential bus treatments are successful;
- Automatic Vehicle Locator system for buses is under development.

4. Hartford - CTT

Basic Information

- There is one street bus lane and one HOV facility on freeway (3+).

Distinct Features:

- "The state is thinking to reduce HOV lane restriction to 2+" (a case of backsliding in

bus preferential treatments).

Comments:

- When the HOV lanes were constructed, the parallel general purpose roadways were also widened, thus greatly diminishing the attractiveness of the HOV facility and its effectiveness.

- The impression from the answers in the questionnaire is that the agency has not done much to improve its bus services, and that it does not have any support from the City.

5. Houston - METRO

Basic Information:

- Five bus lanes on streets (8 km.); 6 HOV lanes (2+) on freeways (152.8 km).

Distinct Features:

- Good results of the bus right-of-way improvements;
- There is no "Transit First Policy".

6. Los Angeles - RTD

Basic Information:

- One bus lane and two HOV lanes (3+) with total length of 70.4 km; 48 intersections with extended phases for buses.

Comment:

- Answers are very brief.

7. New Jersey - NJT

Basic Information:

- Three bus lanes on streets (in Newark and Philadelphia, total length 8 km); contra-flow I-495 Lincoln Tunnel approach bus lane (6.4 km).

Distinct Feature:

- Shelter maintenance is a big problem.

8. Oslo - Norway

Basic Information

- Extensive network of bus lanes on streets (35 km), two busways (6 km) and two bus lanes on freeways (8 km).

Distinct features

- 20% of the highway toll funds are used to improve the transit system
- Automatic vehicle monitoring system under installation (1993)

9. Ottawa - OC Transpo

Basic Information:

- Developed, well-planned bus system, supported by the public and land use development policies.

- Many forms of bus priority treatments in use:

- Bus lanes - 9.3 km;

- Bus malls - 0.8 km;

- Bus lanes on freeways - 15.5 km;
- Exclusive busways (Transitways) - 25.7 km.
- Total length of **exclusive bus facilities: 5 1.3 km.**

Distinct Features:

- Automatic Vehicle Location and Control System under development.
- There is only one HOV (3+) lane. All other facilities are reserved for buses only; transit is distinctly favored.
- Exclusive facilities include diverse solutions: busways, bus lanes on freeways, in malls, on streets (sometimes second from curb; sometimes two lanes at bus stops).
- Busways have been built to the newly developed residential zones, that are planned along such transitway.
- **“Due to success of transit, there have been no major increases to road capacity in the central areas since 1971 and the number of cars leaving the central area in the PM peak hour has actually declined, although employment and total person-trips have continued to increase”.**

10. Pittsburgh - PATransit

Basic Information:

- Four bus lanes on streets (4.5 km); two busways (17.3 km); one HOV lane on freeway (3+, 6.4 km).

Distinct Features:

- Very positive experience with the bus right-of-way improvements.
- Program for provision of shelters and transit maps at selected locations.
- Ridership has increased **on** routes operating on HOV/Busway facilities
- Bus signal pre-emption program under development.

Comments:

- “More coordination of land use/zoning with transit is needed”;
- “Transit funding level should be increased”.

11. San Antonio - VIA Metropolitan Transit

Basic Information:

- Six bus lanes on streets (4.24 km); 11 recently developed off-street transit facilities (stations), 6 of them with park-and-ride lots.

Distinct Features:

- There **is** so called “Tri-party project” that includes an integrated set of transit, traffic and pedestrian flow improvements, mostly in CBD. As a part of this project many intersections, signaling, sidewalks and transit amenities have been improved.
- Problems with mall store owners who forced the transit agency to remove its facilities from the mall property.
- Good cooperation between transportation agencies and multimodal approach.

12. San Francisco - MUNI

Basic Information

- There are only street bus lanes (19 km), mostly on one-way streets; they are defined

as BUS + taxi only.

Distinct Features:

- Curb bulbs or islands are being constructed on some streets.
- There has been an organized effort to increase spacing of bus stops, but it is opposed by the elderly and disabled.
- Contract with private firm to install and maintain 1000 transit shelters in trade for permission to advertise.
- AVM System abandoned since it proved to be unreliable and expensive.
- The City of San Francisco Board of Supervisors established a Transit Preferential Street Program in 1973.
- Suggested improvements: focus on self-enforcing approaches such as: signal preemptions, bulbs/islands and signal timing.

13. Seattle - METRO

Basic Information:

- There are extensive bus and HOV priorities:
 - HOV (3+ and 2+) lanes on freeways - 84.9 km.
 - Bus/HOV lanes on streets - 11.7 km.
 - Two busways - 5.0 km.
- CBD tunnel is operated with dual-mode, diesel buses-trolleybuses.

Comment:

It seems that a lot of attention is being paid to develop good bus transit system. These efforts are mostly supported by the public and by the City Planning Department, but City Public Works Department is generally indifferent and hostile.

14. Washington - WMATA

Basic Information:

- There are two HOV lanes (3+) with total length of 27.3 km.

Distinct Features

- Transit centers have been created.
- New bus communication center and system is under construction.
- The agency suggests a number of significant steps for bus system improvements and its greater effectiveness in attracting ridership, such as:
 - a. "Provide greater incentives to use public transit (expanded employee subsidized pass program)";
 - b. "Create disincentives to using automobiles (higher parking fee, reduce/eliminate free employer provided parking)";
 - c. "Create more HOV and Exclusive bus lanes".

Comment:

The two HOV lanes on freeways are considered to be very successful (all answers about the results of the right-of-way improvements are described as "major"). No other form of bus priority treatment is mentioned.

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